Rem No 1 12/13

In the Circuit Court

OF THE UNITED STATES

FOR THE SOUTHERN DISTRICT OF NEW YORK.

IN EQUITY.

WILLIAM B. SICKELS AND OTHERS.

vs.

DAVID L. YOUNGS AND STEPHEN CUTTER.

Pleadings, Order for Feigned Issue, and Proceedings and Evidence on Trial of Feigned Issue before Judge Betts and a Jury, at New York, from Dec. 20th, 1854, to Jan. 13th, 1855.

[The Evidence on the Trial was reported by JAMES T. ROBERTS and ADOLPHUS F. WARBURTON, Short-Hand Reporters, 115 Nassau st., New York.]

CHARLES M. KELLER,
EDWARD N. DICKERSON,
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THOMAS A. JENCKES,
SAMUEL BLATCHFORD, } *Counsel for Defendants.*

NEW YORK:
WM. C. BRYANT & CO., PRINTERS, 41 NASSAU ST., COR. LIBERTY.

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INDEX.

	PAGE.
Bill,	1
Answer,	7
Replication,	15
Order for Feigned Issue,	15

PLAINTIFFS' EVIDENCE.

Patent to F. E. Sickels, May 20, 1842,	16
Specification of same,	17
Testimony of Henry B. Renwick,	20
Cross-examination of do.,	36
Re-examination of do.,	54
Testimony of Daniel Barnum,	57
Cross-examination of do.,	60
Testimony of James J. Mapes,	64
Cross-examination of do.,	71
Re-examination of do.,	81
Further cross-examination of do.,	86
Further re-examination of do.,	86

DEFENDANTS' EVIDENCE.

Testimony of William C. Hibbard,	87
Cross-examination of do.,	103
Re-examination of do.,	148
Further cross-examination of do.,	150
Further re-examination of do.,	169
Further re-examination of do.,	176
Further cross-examination of do.,	181
Testimony of Mertoun C. Bryant,	152
Cross-examination of do.,	182
Re-examination of do.,	198
Further cross-examination of do.,	201
Testimony of Thomas B. Stillman,	202

PAGE.
Cross-examination of Thomas B. Stillman,........................ 213
Re-examination of do., ... 247
Further cross-examination of do., ... 251
Testimony of William Clark,.. 252
Cross-examination of do., ... 255
Patent to George H. Corliss, March 10th, 1849, re-issued May 13th, 1851. 255
Specification of same,.. 256
Patent to George H. Corliss, July 29th, 1851,...................... 260
Specification of same,.. 260
Patent to F. E. Sickels, September 19th, 1845,...................... 264
Specification of same,.. 264
Patent to F. E. Sickels, February 24th, 1852,...................... 267
Specification of same,.. 267
Caveat of F. E. Sickels, filed January 14th, 1842.................... 269
File belonging to said Caveat,... 272
Letter of F. E. Sickels to Commissioner of Patents, April 19th, 1844,... 272
Deposition of Robert Robinson, (May 11th, 1853,)..................... 273
Cross-examination of do., (May 12th, 1853,)...................... 277
Re-examination of do., (" ")...................... 282
Further cross-examination of do., (May 12th, 1853,)............... 282
Deposition of Robert Robinson, (December 7th, 1854,)............... 283
Testimony of Peter Hogg,... 284
Cross-examination of do., ... 288
Re-examination of do., ... 288
Further cross-examination of do.,................................ 289
Further re-examination of do.,................................ 292

PLAINTIFFS' EVIDENCE IN REPLY.

Testimony of Henry B. Renwick,...................................... 292
Patent to William Garlin, October 11th, 1841........................ 294
Specification of same,.. 294
Cross-examination of Henry B. Renwick,........................... 304
Re-examination of do., ... 317
Testimony of Daniel Barnum,... 318
Cross-examination of do., ... 319
Re-examination of do. , ... 320

Plaintiffs' Prayers for Instructions,.................................. 320
As to First Issue,... 320
As to Second Issue,... 322
Defendants' Prayers for Instructions, ... 323
As to First Issue,... 323
As to Second Issue,... 324
As to the effect of Corliss' Patents,.............................. 325
Charge of the Court to the Jury,...................................... 326
Defendants' Exceptions,... 345
Verdict of the Jury,.. 346

PATENTS AND DOCUMENTS INTRODUCED.

PAGE.

F. E. Sickels' Patent, May 20th, 1842,........ 16
Specification of same,........ 17
G. H. Corliss' Patent, March 10th, 1849, re-issued May 13th, 1851,..... 255
Specification of same,........ 256
G. H. Corliss' Patent, July 29th, 1851,........ 260
Specification of same,........ 260
F. E. Sickels' Patent, September 19th, 1845,........ 264
Specification of same,........ 264
F. E. Sickels' Patent, February 24th, 1852,........ 267
Specification of same,........ 267
F. E. Sickels' Caveat, filed January 14th, 1842,........ 269
File belonging to same,........ 272
F. E. Sickels' letter to Commissioner of Patents, April 19th, 1844,... 272
W. Garlin's Patent, October 11th, 1841,........ 294
Specification of same,........ 294

EXTRACTS FROM BOOKS INTRODUCED.

Tredgold, vol. 1, page 224, art. 478,........ 170, 174, 177, 311
" " " 261, " 546,........ 170
Farey, page 457,........ 171, 174, 176, 314
" " 461,........ 308
" " 527, 528,........ 171
" " 529,........ 307
" " 530,........ 172, 178, 311
Stuart, vol. 2, page 366,........ 172, 178, 315
Lardner, edit. 1840, page 234,........ 297

In the Circuit Court

OF THE UNITED STATES 1

For the Southern District of New York.

In Equity.

William B. Sickels and others, *vs.* David L. Youngs and Stephen Cutter.	

On the 18th of March, 1853, the plaintiffs filed their bill of complaint, as follows:

Bill of Complaint.

To the Judges of the Circuit Court of the United States for the Southern District of New York:

William B. Sickels, of the city of New York, and Robert
L. Thurston, Henry W. Gardner and Gideon G. Hicks, all
of Providence, in the State of Rhode Island, bring this bill
of complaint against David L. Youngs and Stephen Cutter, 2
both of the city of New York.

And thereupon your orators complain and say, that
Frederick Elsworth Sickels, of the city of New York, and
State of New York, a citizen of the United States, being
the true and original inventor of "new and useful improvements in the manner of constructing the apparatus for lifting, tripping, and regulating the closing of the valves of
steam engines," not known or used before his invention 3
thereof, did apply to the Commissioner of Patents of the
United States for letters patent for such improvement, and

having fully and in all respects complied with all the requi-
sitions of the law in that behalf, and especially having made
4 oath that he really believed himself to be the true inventor
and discoverer of such improvement; and having also paid
into the treasury of the United States the sum of thirty dol-
lars, and presented to the Commissioner of Patents of
the United States a petition setting forth his desire to ob-
tain an exclusive property in the said improvement, and
praying that letters patent might for that purpose be grant-
ed to him, and having also delivered and filed in the said
office of the Commissioner of Patents a written description
of his said improvement, and of the manner of using the
5 same, and accompanied the same with drawings thereof
and written references in such full, clear and exact terms,
as to distinguish the same from all other things before
known, so as to enable any other person skilled in the art
with which the said improvement is most nearly connected,
to make and use the same, which said description was
duly signed by the said Sickels and attested by two witness-
es, the said Commissioner of Patents did thereupon cause
letters patent to be made out in the name of the United
States of America, in due form of law in all respects, bear-
6 ing date on the twentieth day of May, eighteen hundred
and forty-two, whereby was granted to the said Frederick
E. Sickels, his heirs, administrators and assigns, for the term
of fourteen years from the date thereof, the full and exclu-
sive right and liberty of using and vending to others to be
used, the said improvement, which is entitled in said letters
patent "new and useful improvements in the manner of con-
structing the apparatus for lifting, tripping and regulating
the closing of the valves of steam engines," and the said
letters patent having been signed by Daniel Webster,
Secretary of State, and countersigned and sealed with the
7 seal of the Patent Office by Henry L. Ellsworth, Commis-
sioner of Patents, and the same having been duly recorded,
were issued and delivered to the said Sickels, all which will
more fully appear in and by said letters patent, or a copy
thereof hereto annexed, to which for greater certainty your
orators crave leave to refer.

And your orators further show unto your honors, that on
or about the eleventh day of January, eighteen hundred
and forty-two, the said Frederick E. Sickels did, by his deed
8 of that date, assign to one Truman Cook, of the city of New
York, in the State of New York, one-half the right, title
and interest, which he should have in the said letters patent
when the same should be granted to him, for, to and in the
United States of America, for and during the full term for
which said letters patent might be granted, which said as-
signment is recorded in Liber , page , at the Patent

Office, in Washington ; and the said Truman Cook did, by 9
deed dated the eleventh day of December, eighteen hundred and forty-six, assign back his one-half the right, title and interest to the letters patent and invention, to the said Frederick E. Sickels, which said assignment was recorded in Liber G, page 108, of Transfers of Patent Rights, in the Patent Office at Washington, on the sixteenth day of January, eighteen hundred and forty-seven. And the said Frederick E. Sickels did, by his deed dated the fourth day of August, eighteen hundred and forty-eight, assign one-half of his
right, title and interest to the said letters patent and inven- 10
tion, to the said Truman Cook, which said assignment was recorded in Liber , page 454, of Transfers of Patent Rights, in the Patent Office at Washington, on the eighth day of August, eighteen hundred and forty-eight.

And the said Frederick E. Sickels and the said Truman Cook, being joint owners of said letters patent and invention, did by their deed dated the fifth day of August, eighteen hundred and forty-eight, assign all their right, title and interest to the said letters patent and invention, to one William B. Sickels, which said assignment was recorded in Li-
ber , page 458, of Transfers of Patent Rights, in the Pa- 11
tent Office at Washington, on the eighth day of August, eighteen hundred and forty-eight.

And the said William B. Sickels did, by his deed, dated the seventeenth day of May, eighteen hundred and forty-nine, license the said Frederick E. Sickels to make, construct and use, and vend to others to be used for land engines throughout the United States, all his right, title and interest to the letters patent and invention.

And afterwards, to wit, on the thirteenth day of April, eighteen hundred and fifty, by an agreement of two parts,
made by and between the said Frederick E. Sickels and one 12
Charles T. James, of Providence, in the State of Rhode Island, duly executed and dated on the day and year last aforesaid, the said Frederick E. Sickels did transfer, assign, grant, sell, release, convey and confirm to the said Charles T. James, all his right, title and interest to the letters patent and invention for land engines, as the same was granted to him by the said William B. Sickels.

And afterwards, to wit, on the sixteenth day of October,
eighteen hundred and fifty-two, by an agreement of two 13
parts, made by and between the said Charles T. James and Robert L. Thurston, Henry W. Gardner and Gideon G. Hicks, all of Providence, in the State of Rhode Island, duly executed and dated on the day and year last aforesaid, the said Charles T. James did transfer, assign, grant, sell and release, convey and confirm to the said Robert L. Thurston, Henry W. Gardner and Gideon G. Hicks, all his right, title

14 and interest so granted to him by the said Frederick E. Sickels to the letters patent and invention for land engines, for the United States.

And your orators further show unto your honors, that heretofore, viz., at the term of this honorable court, begun and holden at New York, within and for the Southern District of New York, on the fifth day of December, in the year of our Lord one thousand eight hundred and forty-three, the said Frederick E. Sickels and Truman Cook, being then the owners in common of said letters patent, impleaded John F. Rodman in an action of trespass on the
15 case, wherein they declared against him for a violation of the exclusive privileges secured to them by the letters patent by manufacturing and selling steam cut-offs substantially the same in their construction as the said steam cut-offs secured to the said Frederick E. Sickels and Truman Cook by the said letters patent; and the said John F. Rodman having pleaded that he was not guilty, in manner and form, as the said plaintiff had declared against him, and issue being joined thereon, the cause was submitted to a jury, who returned their verdict therein upon oath, and found that the said John F. Rodman was guilty in manner and form, as the said
16 plaintiffs had declared against him, and assessed damages to the amount of two hundred and seventy-five dollars and upwards, and found that the said F. E. Sickels was the first and original inventor of the thing patented by him.

And your orators further show unto your honors, that the defendants herein, David L. Young and Stephen Cutter, are infringing those rights so secured to your orators by letters patent, by using and operating an engine constructed substantially on the same plan patented by said Sickels, that is to say, they use an engine in which the valves are
17 opened by lifters, having on them catches which are detached from the valve stems at the desired point by a cam or stop, so as to permit the valves to close rapidly by the force of gravity or by springs, and they regulate the descent of such valves, and prevent them from slamming, by using a cylindrical vessel containing air, and so constructed that a piston descends in it freely to a certain point, and there is arrested and protected from slamming by the fluid contined in a close chamber under it, substantially in the man-
18 ner patented as aforesaid, and continue to use the same and refuse to desist from such use, all which is contrary to equity and good conscience.

To the end therefore, that the said defendants may, if they can, show cause why your orators should not have the relief hereby prayed, and may upon their several and corporal oaths, and according to the best and utmost of their several and respective knowledge, remembrance, information and belief, full, true, direct and perfect answer make to the

matters set out in this bill, and more particulary to the following, that is to say— 19

1st. Whether the said letters patent were granted and issued as above stated?

2d. Whether the several grants and assignments to the several persons hereinbefore mentioned, were made as is above stated?

3d. Whether the said action at law was commenced and prosecuted, and the said verdict was recovered as is above stated?

4th. Whether the said defendants at any time, and when
and during what period of time, either severally, or each 20
by himself, or jointly with any and what other person or persons, have used an engine having an apparatus for lifting, tripping, and regulating the closing of the valves of steam engines, substantially the same as the invention patented by the said F. E. Sickels, and where, and whether or no the same was not used of substantially the same form and in substantially the same manner as the apparatus for lifting, tripping, and regulating the closing of the valves of steam engines patented by the said F. E. Sickels, used by
the plaintiffs, (your orators,) and how the same differed 21
therefrom, if at all?

And that the said defendants may answer the premises, and that they may be decreed to account for and pay over to your orators all such gains and profits as your orators might have made by the use of the said improvement for the time and in the manner in which the defendants have used the same, and that they may be restrained by an injunction issuing out of this honorable court according to
the form of the statute in such case made and provided, 22
from using any more an engine having an apparatus for lifting, tripping, and regulating the closing of the valves of steam engines substantially the same in its construction as the invention patented as aforesaid and used by your orators according to said letters patent, and that your orators may have such further or other relief as the nature of the case may require, and to your honors may seem meet.

May it please your honors to grant unto your orators not
only a writ of injunction conformable to the prayer of this 23
bill, but also a writ of subpœna, directed to David L. Youngs and Stephen Cutter, commanding them and each of them to appear and answer unto this bill of complaint, and to do and receive what to your honors shall seem meet.

And your orators, as in duty bound, will ever pray, &c.

Edwd. N. Dickerson,
Solicitor,
And of Counsel with Complts.

24 UNITED STATES OF AMERICA, } ss.:
District of Rhode Island, }

Robert L. Thurston, Henry W. Gardner, and Gideon G. Hicks, the complainants in the above bill of complaint named, being duly sworn according to law, did depose and say, that the matters and things contained in the above bill of complaint, so far as they relate to their own acts and deeds, are true, and so far as they relate to the acts and deeds of others, they verily believe them to be true, and further say not.

ROBERT L. THURSTON.
25 HENRY W. GARDNER.
GIDEON G. HICKS.

Sworn and subscribed before me, this }
25th day of November, A. D. 1852, }

JOHN S. PITMAN,
Clerk of U. S. Circuit Court
for Rhode Island.

UNITED STATES OF AMERICA, } ss.:
Southern District of New York, }

William B. Sickels, being duly sworn according to law,
26 deposeth and saith, that the matters and things contained in the foregoing bill, so far as they relate to his own acts and deeds, are true, and so far as they relate to the acts and deeds of others, he verily believes them to be true, and further saith not.

WM. B. SICKELS.

Sworn and subscribed this }
15th day of March, 1853, }

JOSEPH BRIDGHAM,
U. S. Comr.

27 UNITED STATES OF AMERICA, } ss.:
Southern District of New York, }

Frederick E. Sickels, being duly sworn according to law, deposeth and saith, that he is the person spoken of in the foregoing bill as the inventor of the thing patented by him as therein set forth; that at the time when he applied for letters patent as therein set out, he verily believed himself to be the inventor of what he then patented, and that he now doth verily believe that he was the first and original
28 inventor of what he then patented, as the same is set out and described in the foregoing bill, and further saith not.

F. E. SICKELS.

Sworn and subscribed before me, }
this 17th day of March, 1853, }

R. E. STILWELL,
Dep. Clerk.

On the 21st day of May, 1853, the defendants filed their 29
answer as follows :

Answer of Defendants.

CIRCUIT COURT OF THE UNITED STATES.

Southern District of New York, ss. :

William B. Sickels, et al., *vs.* Youngs & Cutter.	April Term, 1853. In Equity.

The answer of David L. Youngs and Stephen Cutter to the
bill of complaint of William B. Sickels, of the city and
State of New York, and Robert L. Thurston, Henry W. 30
Gardner, and Gideon G. Hicks, all of Providence, in the
State of Rhode Island, &c.

These defendants reserving to themselves all right of exception to the said bill of complaint, for answer thereunto, or to such parts thereof as they are advised are material for them to make answer unto, answering, say :

That they have been informed and believe it to be true,
that one Frederick Elsworth Sickels, of the city and State of
New York, did apply to the Commissioner of Patents of the 31
United States for Letters Patent for improvements in the
manner of constructing the apparatus for lifting, tripping,
and regulating the closing of the valves of steam engines,
and that letters patent for such improvements were granted
to him upon such application, bearing date the twentieth
day of May, A. D. 1842 ; but these defendants, for greater
certainty, crave leave to refer to the original letters patent
when the same shall be produced ; and they do not admit 32
that the said Sickels was the true and original inventor of
said improvements, or that the same were not known and
used before his application for letters patent therefor, or
pretended invention thereof, but they are informed and believe that the contrary thereof is true.

And these defendants further answering say, that they
know not and have not been informed, save by the complainants' said bill, and cannot set forth as to their belief or
otherwise, whether the said Frederick E. Sickels did, on or 33
about the 11th day of January, 1842, by his deed of that
date, assign to one Truman Cook, of said city of New York,
one-half of the right, title and interest which he should
have in the said letters patent when the same should be
granted to him, for, to and in the United States of America,

34 for and during the full term for which said letters patent
might be granted; or whether the said Truman Cook did
by his deed, dated the 11th day of December, A. D. 1846,
assign back one-half the right, title and interest to the let-
ters patent and invention to the said Sickels; or whether
the said Sickels did by his deed dated the fourth day of Au-
gust, A. D. 1848, assign one half the right, title, and inter-
est to the said letters patent and invention to the said
Truman Cook; or whether the said Frederick E. Sickels
and Truman Cook, being joint owners of said letters patent
35 and invention, did by their deed dated the fifth day of
August, A. D. 1848, assign all their right, title and interest
to the said letters patent and invention to one William B.
Sickels; or whether the said William B. Sickels did by
his deed dated the 17th day of May, A. D. 1849, license the
said Frederick E. Sickels to make, construct, and use and
vend to others to be used for land engines throughout the
United States, all his right, title and interest to the letters
patent and invention; or whether afterwards, to wit, on the
30th day of April, A. D. 1850, the said Frederick E.
Sickels did transfer, assign, grant, sell, convey, release, and
36 confirm to one Charles T. James, all the right, title, and in-
terest to the letters patent and invention for land engines, as
the same was granted to him by the said William B. Sickels;
or whether the said Charles T. James did on the 16th day
of October, 1852, transfer, assign, grant, sell, release, con-
vey and confirm o the complainants, Robert L. Thurston,
Henry W. Gardner and Gideon G. Hicks, all the right,
title, and interest granted to him the said James by the
said Frederick E. Sickels to the letters patent and invention
for land engines for the United States, but leave the said
37 complainants to make proof of the same in such manner as
they may be advised.

And these defendants further answering say, that they do
not know and have not been informed, save by the com-
plainants' bill, and cannot set forth as to their belief whe-
ther at the Term of this honorable court, begun and holden
at New York, within and for the Southern District of New
York, on the fifth day of December, A. D. 1843, the said
Frederick E. Sickels and Truman Cook, as the owners in
38 common of said letters patent, impleaded John F. Rodman
in an action of trespass on the case wherein they declared
against him for a violation of the exclusive privileges se-
cured to them by the letters patent, by manufacturing and
selling steam cut-offs, substantially the same in their con-
struction as the said steam cut-offs secured to the said Fre-
derick E. Sickels and Truman Cook by the said letters
patent, or whether the said JohnF. Rodman pleaded thathe
was not guilty in manner and form as the said plaintiffs had

declared against him ; and upon issue being joined thereon, 39
the cause was committed to a jury, who returned their verdict thereon upon oath, and found that the said John F. Rodman was guilty in manner and form, as the said plaintiffs had declared against him, and assessed damages in the sum of two hundred and seventy dollars and upwards, and found that the said Frederick E. Sickels was the first and original inventor of the thing patented by him, but leave the complainants to make proof of the same in such manner as they may be advised.

And these defendants further answering deny that they 40
are infringing any right secured to the complainants by letters patent, by using and operating an engine constructed substantially on the plan patented by said Sickels, that is to say, they do not use an engine in which the valves and valve gearing are constructed in the same or in substantially the same manner as the valves and valve gearing described in the specification of said Sickels' patent, as set forth in said bill, or in which there is any combination and arrangement of the valve-stem, a spring on the lifter, and an adjustable sliding piece with its wedges or inclined
planes and their immediate appendages, in the manner de- 41
scribed in said specification, so as to co-operate with each other and to effect the tripping of the valves and the cutting off of the steam substantially in the manner therein set forth ; nor, in the engine used by these defendants, do they regulate the closing of the valves and prevent them from slamming, by means of a water reservoir furnished with a piston or plunger attached at the lower end of the valve stem and operating within an adjustable cup or secondary reservoir, substantially in the manner described in said specification ; nor do they use any contrivance to regulate
the closing of the valves, or to prevent them from slam- 42
ming, nor any water reservoir whatever, nor any adjustable cup or secondary reservoir, nor any other contrivance for effecting the purpose intended and described in said specification ; but in all that relate to the valves, valve gearing, and the manner of opening and closing the valves, and the cutting off of the steam, and the manner in which and purpose for which it is done, the engine of the defendants differs entirely from that described in the patent of
said Sickels, in the mechanical devices used, and in the 43
manner in which they are combined and arranged, and in their mode of operation and result.

And these defendants further answering say, that they are using a steam engine constructed by George H. Corliss and Edwin J. Nightingale, both of the city and county of Providence and State of Rhode Island, &c., and that the said engine contains the improvements invented by the said

44 George H. Corliss and for which he holds letters patent, as
follows: one for "improvement in cut-off and working the
valves of steam engines," granted on the 10th day of March,
A. D. 1849, and re-issued on the 13th day of May, A. D.
1851, and one for "improved cut-off gear," granted on the
29th day of July, A. D. 1851, and that the said improve-
ments are substantially different from those described in
the specification of said Sickels.

And they further say, that these improvements differ
from the apparatus for lifting, tripping and regulating the
45 closing of the valves of steam engines patented by the said
Sickels in the following particulars, among others, viz.:
that the alleged invention of said Sickels, as described in
the specification annexed to said bill, requires the use of a
peculiar kind of valves, to wit, the kind called puppet
valves, and a kind of valve-gearing adapted to the opening
and closing of such valves, of which the kind in most gene-
ral use is described in said specification; and such valves
when tripped and permitted to fall upon their seats after
being lifted from them by the lifters, require to have some
46 method of regulating their closing in order to prevent their
slamming upon their seats, and breaking or injuring the
valve and valve seat by the force of their descent; and to
prevent them from slamming, and to regulate their closing,
a water reservoir is used with a piston or plunger attached
to the valve stem, operating within an adjustable cup or
secondary reservoir, the intention being to cause the water
to offer a determined degree of obstruction to the descent
of the plunger, and to admit of this being regulated, so that
the passage of the water between the cup and the plunger
47 will be sufficient to allow of the descent of the plunger,
whilst it shall be so obstructed as to take off the force of
the blow of the valve, in order that the descent of the valve
shall be obstructed just before it arrives at its seat and
closes the port, and for this purpose, water, oil, or some
other incompressible fluid is necessary, as described and
claimed by said Sickels. Whereas, the valves used in the
machine of the defendants are sliding valves, or valves
which slide upon circular faces, and are never lifted from
and cannot fall upon the seats, or slam, or break, or injure
48 their faces or their seats by the force of their descent, or
otherwise; and the valve gearing by which the valves are
opened and closed is not of the kind described in the speci-
fication of said Sickles, and to which alone his alleged in-
vention is adapted, but is of an entirely new variety, being
the invention of said Corliss, and described in the specifica-
tion annexed to his patent of March 10th, 1840, as afore-
said; and in the machine of the defendants there is no
contrivance for regulating the closing of the valves, or to

prevent them from slamming, or to obstruct their descent, 49
or to check their closing by means of a water reservoir, or
any reservoir constructed in substantially the same manner,
or acting upon the same principle, or producing the same
result as the water reservoir described in the specification
of said Sickels; but in the defendants' machine the valve be-
ing attached to a rocker shaft entering the valve chamber,
is made to slide over the port for the purpose of shutting off
the steam, by means of a weight attached to an arm or pro-
jecting lever on the rocker shaft, and no contrivance is
used or required for checking the motion of the valve
while the port is being closed or for the purpose of closing 50
it gradually, but the port is entirely closed by the free ac-
tion of the weight upon the valve, and in order to arrest
the motion of the weight after its office of closing the valve
has been performed, the weight is dropped into a cylindri-
cal socket within which it compresses the air, and thus
forms an elastic cushion by which its descent is arrested;
and in order that the fall and action of the weight may not
be checked until after the valve is entirely closed, an open-
ing is made in the side of the cylinder or socket, at a point
which the weight will reach after the valve is closed, so 51
that the weight will fall freely to that point and then be
arrested by confining and compressing the air, and thus
form an elastic cushion to prevent any jar of the machinery
from the use of a detached weight after the port is closed.

And further, that in the alleged invention of said Sickels,
as described in the specification annexed to said bill, the
detachment of the valve stem from the lifter is effected by
means of an adjustable sliding piece, upon the face of which
are two projecting wedge-formed pieces or inclined planes
which serve to open the ends of the spring upon the lifter, 52
which embrace the sides of the valve-stem, and thus libe-
rate the valve-stem, and permit the valve to fall, and the
position of these inclined planes may be so adjusted by
means of a set screw and by reversing the sliding piece
with its wedges or inclined planes, that the cut-off may be
effected at any portion of the stroke; whereas, in the
machine of the defendants there is no sliding piece, with
wedges or inclined planes for the purpose of detaching the
valve, but the connecting rods which receive a recipro-
cating motion from the eccentric as modified by a wrist 53
plate to which the rods are attached, have also a lateral
motion imparted to their extremities, which take hold of
the rocker arm of the valves by means of hooks, so that, by
placing a fulcrum at a certain point against which the con-
necting rods can impinge in their lateral movements during
the first half of the stroke of the piston, the hooks are press-
ed away from the toes of the rock shafts which work the

54 valves, and the valves are thus released from the action of the gear which opens them, and are closed by weights, as above described; and the fulcrum upon which the connecting rod thus detaches itself from the valves in the machine of the defendants is an adjustable stop, so constructed and placed that the sliding rod which adjusts its position is connected with the slide of the governor, and as that is moved, the point at which the cut-off is effected is varied, and thus a method of regulating the motion is effected by
55 means of the regulator by combining the regulator with the catches that liberate the steam valves by means of movable cams or stops, as described in the specification annexed to the patent of said Corliss, as aforesaid.

And these defendants aver that the differences aforesaid are substantial and material as well in the mechanical devices used, as in the manner in which they are combined and arranged, and in their mode of operation, and in the result and effect produced thereby.

And these defendants further answering say, that they
56 are informed and believe that the said Frederick E. Sickels, from whom the said complainants pretend to derive their title to the improvements described in the letters patent referred to in their said bill of complaint, was not the original and first inventor or discoverer of the things patented, or of substantial parts thereof claimed as new, that is to say, that he was not the original inventor and discoveror of any one of the several supposed inventions or improvements specified and claimed in letters patent of the
57 United States, granted to the said Sickels on the 20th day of May, A.D. 1842, for "certain improvements in the manner of constructing and arranging the apparatus for lifting and tripping the valves of steam engines, and by which the steam may be more readily cut off at any desired part of the stroke, than by the means heretofore adopted, and also an improved water reservoir and plunger, which serve to prevent the slamming of the valves in closing, and consequently to preserve them in good working order for a great length of time," in the words following, to wit:
58 "What I claim therein as new, and desire to secure by letters patent, is, first, the manner in which I have combined and arranged the valve-stem, the spring on the lifter, the adjustable sliding-piece, with its wedges or inclined planes, and their immediate appendages, so as to co-operate with each other, and to effect the tripping of the valves, and the cutting off of the steam substantially in the manner set forth;" and "I also claim the manner of regulating the closing of the valves, and of effectually preventing them from slamming, by means of a water reservoir furnished with a piston or plunger attached

at the lower end of the valve-stem, and operating within 59
an adjustable cup or secondary reservoir, so as to effect the purpose intended, upon the principle and substantially in the manner herein described and made known."

And these defendants are informed and believe, and they intend to prove, that anterior to the supposed discovery of the said supposed inventions by the said Sickels, they were respectively known and used in the city of New York, in the State of New York, in Pittsburgh, in the State of Penn-
sylvania, and in the city of Boston, in the State of Massa- 60
chusetts, and a knowledge of the same and of such use at New York, Boston and Pittsburgh as aforesaid, was possessed and will be proved by the following named persons :

Phineas Bennett, of the city of New York.
Livingston S. Bartholemew, "
Ezekiel Williams, "
Edward S. Bartholemew, "
Thomas Bartholemew, late of the city of New York, now in Spain.
John Palmer, late of the city of New York, now in Cuba.
Peter Hogg, of the city of New York. 61
Cornelius H. Delamater, "
Anselm St. John, "
Oliver Byrne, "
David Leavitt, "
William A. Lighthall, "
George Hawes, "
Jeremiah S. Bunce, "
George Birkbeck, Jr., "
Archer Guion, "
Joseph Belknap, "
James Cunningham, late of "
Robert Robinson, " 62
Isaac Newton, "
James MacFarland, of Brooklyn, N. Y.
William Cobb, of Tarrytown, N. Y.
Peter H. Watson, of Washington City, D. C.
Edward S. Renwick, " "
John Sheriff, Pittsburgh, Pa.
John B. Bell, "
John Smith, "
Matthew Smith, "
Cadwallader Evans, " 63
Benjamin Crawford, of Alleghany City, Pa.
George E. Sellers, of Cincinnati, Ohio.
Miles Greenwood, " "
Andrew Cathcart, of Madison, Indiana.

And these defendants further answering say, that ante-

rior to the supposed inventions by the said Sickels, they were respectively described in the following public works:

"Historical and Descriptive Anecdotes of Steam Engines,
64 and of their inventors and improvers. By Robert Stuart, Civil Engineer. 2 vols. London: Wightman & Cramp, Paternoster Row, 1829," and particularly at vol. 2nd, p. 366, of said public work, and the plates there referred to.

"The Steam Engine, its invention and progressive improvements: an investigation of its principles, and its application to navigation, manufactures and railways, &c. By Thomas Tredgold, Civil Engineer, &c. New edition, 2
65 vols., 4to. London, 1838," and particularly at p. 224, § 478, and at p. 261, § 546, vol. 1, and at plate 9, vol. 2, of said public work.

"Encyclopædia Metropolitana, vol. 8, 4to. London, 1845."

"A System of Mechanical Philosophy. By John Robinson, LL.D. Ed. by David Brewster. Vol. 1, 8vo. edition 1822."

"An Epitome of the Elementary Principles of Natural and Experimental Philosophy, comprising a copious ac-
66 count of the invention, progress, and present state of the steam engine. By John Millington. 8vo. London, 1823."

"A Treatise on the Steam Engine, historical, practical, and descriptive. By John Farey, Engineer. London: Printed for Longman, Rees, Orme, Brown, and Green, Paternoster Row, 1827."

And these defendants further answering say, that the fuel for the boilers of their engine is composed mainly from the chips, shavings, splinters, blocks and waste timber of the different workshops which derive power from and are
67 operated by it, and it would be impossible for them to keep any account of the same, or to compare the same with the quantity of fuel required for any other engine.

And these defendants deny all and all manner of unlawful combination and confederacy wherewith they are by said bill charged, without this—that there is any other matter, cause, or thing in the said complainants' said bill of complaint contained, material or necessary for these defendants to make answer unto, and not herein and hereby well and sufficiently answered, confessed, traversed and
68 avoided, or denied, is true to the knowledge or belief of these defendants, or either of them—all which matters and things these defendants are ready and willing to aver, maintain and prove, as this honorable Court shall direct, and pray to be hence dismissed with their reasonable costs and charges in this behalf most wrongfully sustained.

David L. Youngs,
Stephen Cutter.

T. A. Jenckes,
Solr. for Defendants.

SOUTHERN DISTRICT OF NEW YORK, } ss.: 69
City and County of New York. }

David L. Youngs and Stephen Cutter, the defendants in this suit, being duly sworn, depose and say, that they have heard read the foregoing answer, and know the contents thereof, and that the same are true of their own knowledge, except as to those matters therein stated on their information and belief, and as to those matters they believe it to be true.

Subscribed and sworn to before }
me, this 21st day of May, 1853, } 70

R. E. STILWELL,
Dep. Clerk.

To this answer the plaintiffs filed a general replication, in the usual form.

An application for a provisional injunction having been made by the plaintiffs to His Honor Mr. Justice Nelson, he made the following order:

At a Special Term of the Circuit Court of the United States of America, for the Southern District of New York, in the Second Circuit, held at the City Hall, in the City of New York, on Thursday, the seventh day of September, in the year of our Lord one thousand eight hundred and fifty-four. 71

Present,—The Honorable SAMUEL NELSON, an Associate Justice of the Supreme Court of the United States.

WILLIAM B. SICKELS and others
vs.
DAVID L. YOUNGS and STEPHEN CUTTER.

Motion for preliminary injunction: Sickels' Patent for Cut-off in Steam Engine. 72

THE SAME,
vs.
GEORGE H. CORLISS and JOHN BARSTOW.

Ordered, that the following questions be tried at law before a Jury, in the first above named cause, at the next regular term of this Court, to be held in the Southern District of New York, namely: 73

First,—Whether or not the construction, arrangement, or combination of the apparatus used by the defendants for

74 the more readily cutting off steam in working the steam engine, as charged by complainants in their bill, are substantially identical with the construction, arrangement, or combination of the apparatus described in and claimed by the complainants under the patent granted to F. E. Sickels 20th May, 1842, for the more readily cutting off steam in working the steam engine ; and,

Second,—Whether or not the construction and arrangement of the apparatus for preventing the slamming of the valves in closing, used by the defendants, as charged in the
75 bill, are substantially identical with the construction and arrangement of the apparatus described in and claimed by the complainants under the aforesaid patent.

And further ordered, that the decision upon the motions for injunctions in the above cases be postponed till the coming in of the finding of the jury on these issues.

[A copy.]

J. W. Nelson,
Clerk.

76 The issues so ordered to be tried came on for trial before His Honor Judge Betts and a jury, at the city of New York, on the 20th of December, 1854.

The case was opened to the jury on the part of the plaintiffs, by Benjamin F. Thurston, Esq., of Providence, R. I.

The court then adjourned to December 21st, 1854, at 11 o'clock, A. M.

December 21st, 1854, 11 o'clock, A. M.

The plaintiffs read in evidence letters patent of the United
77 States granted to Frederick E. Sickels, May 20th, 1842, for "new and useful improvements in the manner of constructing the apparatus for lifting, tripping and regulating the closing of the valves of steam engines," of which (without the drawings) the following is a copy:

THE UNITED STATES OF AMERICA.

To all to whom these letters patent shall come :

Whereas Frederick Elsworth Sickels, New York, has
78 alleged that he has invented new and useful improvements in the manner of constructing the apparatus for lifting, tripping, and regulating the closing of the valves of steam engines, which he states has not been known or used before his application ; has made oath that he is a citizen of the United States ; that he does verily believe that he is the original and first inventor or discoverer of the said improvements, and that the same hath not, to the best of his knowledge and belief, been previously known or used ; has paid

into the Treasury of United States the sum of thirty dollars, 79
and presented a petition to the Commissioner of Patents,
signifying a desire of obtaining an exclusive property in the
said improvements, and praying that a patent may be
granted for that purpose.

These are therefore to grant, according to law, to the said
Frederick Elsworth Sickels, his he rs, administrators or as-
signs, for the term of fourteen years, from the twentieth
day of May, one thousand eight hundred and forty-two, the
full and exclusive right and libe ty of making, construct-
ing, using, and vending to others to be used, the said im- 80
provements, a description whereof is given in the words of
the said Frederick Elsworth Sickels, in the schedule here-
unto annexed, and is made a part of these presents.

In testimony whereof, I have caused these letters to be made patent, and the seal of the Patent Office has been hereunto affixed.

[L. S.] Given under my hand, at the city of Washing-
ton, this twentieth day of May, in the year of
our Lord one thousand eight hundred and
forty-two, and of the Independence of the 81
United States of America the sixty-sixth.

DANL. WEBSTER,
Secretary of State.

Countersigned and sealed with the Seal of the Patent Office.

HENRY L. ELLSWORTH,
Comr. of Patents.

The Schedule referred to in these Letters Patent, and making part of the same.

To all whom it may concern: Be it known, that I, Fre-
derick Elsworth Sickels, of the city of New York, in the
State of New York, have invented certain improvements in 82
the manner of constructing and arranging the apparatus for
lifting and tripping the valves of steam engines, and by
which the steam can be more readily cut off, at any desired
part of the stroke, than by the means heretofore adopted;
and also an improved water reservoir and plunger, which
serve to prevent the slamming of the valves in closing, and
consequently to preserve them in good working order for a
great length of time.

In the accompanying drawing, A A, figure 1, represents 83
a valve box containing the puppet valves which are to be lifted
and closed; the construction of this part being such as is
well known to engineers and machinists. B is the valve
stem passing through a stuffing box C on the bonnet D of
the valve box. The valve stem is to be raised by the lifter
E, which is acted on in the usual way. F F is a spring

84 which is attached to the shaft C of the lifter, and the outer
ends F of which embrace the sides of the valve stem B.
The upper end of this stem is flattened or has projecting
edges or feathers, A A, which while the valve is being lifted, rest
upon the upper edges of the spring F F, where said feathers
terminate; but when the spring is opened, the stem will be
no longer sustained by it, and it will consequently descend,
and the valve or valves attached to it will be closed. By
means of the apparatus which I have devised, the spring F
may be opened, and the stem B, with its valves, may be
85 tripped at any time during the ascent or descent of the
lifter, and the steam may consequently be cut off at any part
of the stroke of the piston. To effect this there is a standard
H rising vertically from the valve box or bonnet C, so as
that its upper flat end shall be nearly in contact with the
outer ends of the springs F F. This standard sustains an ad-
justable sliding piece I, which may be shifted to any desir-
ed height, and then held in place by means of a set screw
A'. Upon the face of this sliding piece there are two pro-
jecting wedge-formed pieces, or inclined planes B B, which
86 serve to open the ends F' of the springs, and thus to liberate
the stem B. In the position in which the piece I is repre-
sented in this figure, the ends of the spring F would catch
against the outsides of the pieces B B in ascending, and they
would be separated; but in descending, the ends of said
springs would catch against the insides of the wedges or
planes B B, and they would consequently be forced inwards,
and would not be opened; but were the sliding piece I,
with its wedges or inclined planes, reversed, the spring would
then not be opened by the ascent, but would be opened
87 by the descent of the stem. When the stem is liberated, or
tripped at its greatest rise, the steam will be cut off at half
stroke; when tripped at one-half its rise in ascending, the
steam will be cut off at one-fourth of the stroke, and when
at that same point in descending, it will be cut off at three-
fourths of the stroke; and so on of any intermediate point.
The face of the standard H may be graduated, so as instan-
taneously to set the cut-off at any required point by means
of the set screw. In order to cause the stem B to descend
instantaneously when the spring F F is opened, I cause a
88 spring to bear upon it, which spring is situated on the upper
side of the lifter, to which it is attached by one end, whilst
its other end bears upon the stem. In figure 2, which is a
vertical section through the lifter and the valve-stem, C C is
a spring which is fastened to the lifter at D, whilst its outer
end bears on an offset D' on the stem, and serves to give it
a descending impulse the moment it is freed from the spring
F. Figure 3 is a top view of the lifter, the bonnet and
some of their appendages, as designated by the letters of
reference.

J, figure 1, is the water reservoir attached to the lower 89
side of the valve box A. This and the parts within it are
shown in section in figure 4, for the purpose of clearly ex-
hibiting their construction and arrangement. B is a contin-
uation of the valve-stem, and this has affixed to it on its
lower end a plunger or piston K. The interior of the reser-
voir J is cylindrical, and it has within it a cup, or secondary
reservoir, which may be raised or lowered by means of a
graduating screw E E, said screw being furnished with a nut
F, by which it is to be held in place. When the valve stem 90
B descends, the plunger K enters the cup, or secondary re-
servoir, L, into the upper cylindrical part of which it passes
freely and to such depth as may be found necessary, which
is determined by means of the graduating screw E E. The
reservoir J is to contain water, oil or other fluid, say to two-
thirds of its height, more or less; through the plunger K
holes G G are represented as being made for the passage of
water, and H is a valve-like piece which slides up and down
on the lower end of the stem B. This part of the apparatus,
however, may be varied in its form in numerous ways, the 91
intention being to cause the water to offer a determined de-
gree of obstruction to the descent of the plunger, and to ad-
mit of this being regulated. This I have sometimes done
by making the plunger K a flat disk, with a sufficient space
between it and the cavity of the cup L, for the passage of
water sufficient to allow of the descent of the plunger, whilst
it shall be so obstructed as to take off the force of the blow
of the valve. I have in fact essayed the action of the
plunger and of the parts within which it operates, in different
forms, and in all with good effect, that which I have repre- 92
sented being one of the best. An opening furnished with
a stopper may be made through the reservoir as at I, to
supply water when requisite. By means of this apparatus
the valves may be made to shut so silently as scarcely to be
heard, whilst the retardation is so perfectly graduated as
not to be accompanied by any sensible loss of time, as it
takes place in the last moment of their descent only.

Having thus fully described the nature of my improve-
ments in the apparatus for lifting and tripping the valves of
steam engines, and of thereby cutting off the steam at any 93
required part of the stroke, and also of my improved ap-
paratus for regulating the closing of the valves, what I
claim therein as new and desire to secure by Letters Patent
is: first, the manner in which I have combined and arranged
the valve-stem B, the spring F on the lifter, the adjustable
sliding piece I, with its wedges or inclined planes, and their
immediate appendages, so as to co-operate with each other,
and to effect the tripping of the valves, and the cutting off
of the steam, substantially in the manner set forth. I also

94 claim the manner of regulating the closing of the valves and of effectually preventing them from slamming, by means of a water reservoir furnished with a piston or plunger attached at the lower end of the valve-stem, and operating within an adjustable cup or secondary reservoir, so as to effect the purpose intended upon the principle, and substantially in the manner herein described and made known.

FREDERICK ELSWORTH SICKELS.

Witnesses,
WM. J. HASKETT,
WM. M. B. SICKELS.

95 The plaintiffs then called as a witness—

Henry B. Renwick, who, having been duly sworn, was examined by Charles M. Keller, Esq., one of the plaintiffs' counsel, and testified as follows:

Q. Will you please state your residence?

A. No. 21 Fifth Avenue, New York.

Q. I will get you, sir, briefly to state to the jury what is your present occupation, and what have been your means of acquiring a knowledge of the arts and of the progress of inventions. I beg you to lay aside all personal modesty; for
96 the object is to let the jury know what have been your means of information upon the subject.

A. I am at present government inspector of steamboats for the port of New York; I was before that, for nearly five years, in the patent office, as principal examiner of patents; before that I was engaged in making iron myself, and have been in the pursuit of civil and mechanical engineering since I left school.

Q. While you were examiner in the patent office, had you charge of the examination of applications for patents upon
97 steam engines?

A. I had charge of the whole of them.

Q. Have you examined the specification and drawings of the patent granted to Frederick E. Sickels, dated 20th May, 1842?

A. I have, frequently.

Q. Have you seen that apparatus in operation?

A. I have, sir, on steamships and boats plying in and out of New York.

98 Q. State what, in your opinion, is the mode of operation in the patent described, for lifting, tripping and regulating the closing of the valves; state fully your opinion as to every part of the invention found in said patent?

(To this question the defendants' counsel objected, on the ground that the question opened a much wider field of inquiry than was submitted to the Court and jury upon the issues sent to be tried; that the judge who framed the

Renwick

issues had upon the face of them construed the claims of 99
Sickels' patent, and decided each claim to be a claim to the
particular apparatus described by Sickels; that the proper
inquiry to the witness in reference to each branch of the
case, was whether the defendants' apparatus was substantially identical with the apparatus described by Sickles, and
that the question put to the witness was entirely outside of
any issue sent down to be tried. The defendants' counsel
further insisted, that if the Court should be of opinion that
the claims of Sickels' patent were not so construed in the
issues, then this Court should now, on this trial, hold such 100
claims to be each of them a claim to the particular apparatus described, and limit the inquiries to the witness, on each
issue to the point of the substantial identity of the defendants' apparatus with Sickels' apparatus; and they further
insisted, that the Court should, before proceeding any further
in the case, construe the claims of the plaintiffs' patent, and
decide what was embraced in and covered by each of such
claims, and what was embraced in the apparatus of Sickels'
referred to in each issue, in order to furnish a legal standard
of comparison for the experts on the question of identity, 101
and advise them, as matter of law, what was the apparatus
of Sickels, in each branch of the case, with which the defendants' apparatus was to be compared.

The Court overruled the defendants' objections to the
question and allowed it to be put, and declined to make any
ruling at this stage of the case upon the positions taken by
the defendants' counsel as to the effect of the issues, and the
proper construction of the claims of Sickels' patent, and the
necessity that this Court should now decide as to the construction of such claims, and as to what was embraced in 102
the apparatus referred to in the issues, and reserved further
argument and a decision thereon. To which overruling,
declining, reserving and decision, and to each of them, the
defendants' counsel excepted.)

The question was then put to the witness.

A. In this model before me, as in all other steam engines,
there is a certain apparatus for opening and closing the
valve at certain proper periods of time; and I find that in
this patent, or in the apparatus before me, there is a subapparatus, by means of which the valve is detached from
its moving mechanism at any portion of the stroke, and
permitted to cover the opening, while the mechanism which 103
would move it goes on as if the valve had not been detached. I find further, that a portion of that mechanism
which acts to detach the valve at any portion of the stroke,
always latches the valve fast to its moving mechanism before the commencement of a stroke, so that it can be moved
to open its port.

104 *The Court.*—Does this stem, the one which is employed to raise and close the valve, perform any other function in the machinery?

A. None other.

Mr. Keller.—Explain to the jury the combination of parts by which this effect you have stated is produced.

A. I find in this black model, (which I believe is the same as the patent drawing,) a rod which moves in opposite directions, for the purpose of lifting and shutting the
105 valve. That rod, I suppose, is moved in some of the ordinary ways; I do not find it shown here; and I find that between this particular rod, (and we may consider this lifter a portion of the rod,) between this lifter, which is attached to the rod and the valve stem, is found a spring latch, which tends to close of itself and unite the valve-stem and lifter, and which may be opened so as to permit the valve-stem to fall and close at any required portion of the stroke, that opening of the latch being effected by means of this
106 adjustable stop, which may be moved up and down. I find the valve stem has a notch, in which this spring falls and locks it fast to the lifter, and that this catch throws the spring out of the notch.

Q. If that adjustable piece, with its inclined plane, which acts upon the latch, were removed, how would the valve operate?

A. Precisely as it does in an ordinary steam engine, which does not cut off at the steam valve. The steam would follow the piston through the whole course of its
107 stroke; the valve would follow its moving mechanism as it does in an ordinary steam engine.

Q. State to the jury what is the object or purpose of disconnecting the valve from the lifter by which it is opened.

A. The object of disconnecting the valve is to let the valve fall and close the passage which leads from the boiler to the cylinder of the engine, so that the flow of steam may be stopped and that portion of the steam already in the cylinder may be separated from that in the boiler.

Q. Explain to the jury the expansive action of steam, so that they may understand the purpose of cutting off steam
108 to let it work expansively.

A. In making steam from a quantity of water by a given quantity of fuel, suppose you take a handful of coal, which would produce a cylinder full of steam, of the size of a pail, at a pressure of 15 lbs. to the square inch, by the use of that handful of coal you will drive the piston in the pail from one end to the other, with a pressure of 15 lbs. to the square inch, or nearly so. The same quantity of coal applied to the water would produce half a pail full of steam, at a pressure of 30 lbs. Therefore if you were to use in

your boiler steam of 30 lbs. to the square inch, instead of 109
15 lbs., and were to drop your cut-off valve at the instant the piston arrived at half-stroke, you would use up just the amount of steam produced by that coal; but while the piston was going through half the stroke you would have the same power given out by it as would be given out by the piston moving through its whole stroke with a pressure of 15 lbs. After the cut-off takes place the steam begins to expand; it is then acting upon the piston with a pressure of 30 lbs. to the inch, but the piston goes through the other half of its stroke with a pressure commencing at 30 lbs. to
the square inch and ending at 15 lbs. to the square inch, so 110
that the whole of the movement imparted to the piston, after it has passed the half-stroke, is a clear gain above what would be obtained if you used steam of only 15 lbs. and followed through the whole stroke.

Q. What is about the proportion gained by cutting off at half-stroke?

A. That I am unable to tell you exactly. I think it is somewhere about a quarter of the fuel employed, as contrasted with steam following full pressure through the
whole stroke. The piston is acted upon at the instant the 111
cut-off valve is closed, by a pressure of 30 lbs., which diminishes to 15 lbs. at the end of the stroke.

Q. Would not that make an average of 30 per cent.?

A. About. I would state, in speaking of the pressure of steam, that I am speaking of the pressure of steam independent of the pressure of the atmosphere.

Q. Will you state the mechanical parts constituting the combination to effect the lifting and tripping of the valve?

A. The mechanical parts to lift the valve are the rod, the
lifter, the valve-stem, which is attached to the valve, and 112
the catch, which unites the valve-stem with the lifter.

Q. A spring catch?

A. Yes; and the detaching parts are that same spring catch, in connection with an adjustable stop, which forces the spring out of the notch, and permits the valve to close its port.

Q. It may be partly repetition, but the object is to inform the jury fully upon the subject. I will get you to state the particular mechanical function or office which
each member of that combination performs. 113

A. This rod gives motion to the lifter.

Q. Which rod?

A. The rod which takes hold of the lifter gives motion to the lifter keyed upon it. The lifter carries a spring latch, which enters the notch cut in the valve-stem, and while that latch is in possession of the valve-stem, the valve follows the motion of the outside rod. But when the spring

114 latch strikes the adjustable stop, the latch is knocked out of the notch in the valve-stem, and the valve-stem and valve fall, and the valve consequently closes its port.

Q. Are all these essential to the result specified or described in the patent?

A. The outside rod might be dispensed with, and motion might be given directly to the lifter in some other way. All that is necessary to produce the result is, that motion should be given to the valve-stem, by means of some apparatus or other, from which it can be disconnected,
115 and to which it is connected.

Q. Now, sir, will you state whether there is any advantage in closing the valve more rapidly than the return motion of the lifter?

A. There is a great advantage in closing the valve as rapidly as possible. If the valve of a steam-engine could be opened with the velocity of light, it would be better to have it so opened and closed than in any other way—that is, theoretically speaking. In order to cut off steam to great advantage, it is necessary to close the cut-off valve as ra-
116 pidly as possible, and as near the cylinder as possible. If it does not close rapidly, it produces what we technically call wire-drawing—which is the steam dribbling through the opening between the valve and its port, and not acting as effectually as if the passage were opened and closed at once.

Q. Steam passes through a small aperture, and the pressure is reduced?

A. Yes, so that it is not as great in the cylinder as it is in the boiler.

117 Q. Do you know if there are any mechanical devices known as equivalents for the several members of the combination which you have there pointed out, including the valve?

A. Yes, a host of them.

Q. In your opinion, would it require an exercise of the inventive faculties—in other words, would it require invention—in view of the description in Sickels' patent, to substitute for the members of that combination known mechanical equivalents?

118 (This question was objected to by the defendants' counsel, and was ruled out by the court.)

Q. Will you state what, in your opinion, is the mode of operation described in the patent for regulating the closing of the valve?

A. I conceive, sir, that the valve is regulated in its closing by attaching a plunger to the prolongation of the valve-stem, or to some rod rigidly attached to the valve, and by putting round that plunger a vessel containing fluid. The

inside of that vessel is bored out in such a manner that the 119
plunger, in the first part of its descent, shall move at some
distance from the sides of the vessel, so that the fluid can
pass freely between the plunger and the inner side of the
vessel; and at the lower part of the vessel the bore is con-
tracted, so that when the plunger arrives there there shall
be very little passage for the fluid between the plunger and
the sides of the vessel. It follows from this construction,
that when a weight is attached to the piston and dropped
so as to descend, the plunger will fall first through that part
of the vessel where the fluid can easily pass from one side 120
of the plunger to the other, (between the outer side of the
plunger and the inner side of the vessel,) and when it
arrives at the small part of the vessel the motion of the
plunger will be checked, there being scarcely any escape
for the fluid. I conceive the object is to permit the valve
to cover its port as rapidly as possible, and to check it at the
instant it does cover the valve-port.

Q. What would be the consequences to the mechanism
if some such mode of regulating the closing of the valve
were not used?

A. The consequence would be a jar. That weight would 121
fall with accelerated velocity, and when it brought up upon
any stop there would be a jar upon the valve-gear, through
the whole engine; and we know from experience that all
such jars deteriorate an engine and wear it out. The object
is to have an engine work as smoothly as it can, so that there
will be no jar at all.

Q. Is the form of this vessel, above where the fluid
checks the descent of the plunger, material?

A. No, sir, I do not conceive that it is material; it
might be square, circular, or hexagonal. It would be more 122
difficult to guide a plunger into the narrow part, if that
were square or hexagonal, but there would be no difference
in the operation.

Q. Is the kind of fluid to be used material?

A. I do not think it is. I know of different fluids having
been used in the dash-pot; some engineers hold particularly
to one.

Q. Does the term "fluid," in science, include aëriform
gasses?

A. Yes; air, gasses and liquids. It is a generic term. 123

Q. Have you examined the cut-off apparatus of the en-
gine of the defendants?

A. I have seen the engine at work at Youngs and Cut-
ter's shop, and have examined it.

The Court. Does the valve-stem, in its operation, carry
the valve away from the aperture that it closes?

A. It does.

Mr. Keller. Will you examine this model (defendants' model of defendants' engine,) and say whether it corresponds with the engine which you saw at work? State whether it is a correct representation of the cut-off apparatus of the engine of the defendants.
124

A. It corresponds in all essentials. It is precisely the same, except in one respect.

Q. What is that respect?

A. I do not see any means in this model of adjusting the distance between the plunger and the rock-shaft to which the plunger is attached. It may be there, but I do not see it.

Q. Is there a mode of adjustment in the engine?

A. Yes. It appears to me that there is also a difference in the position of the aperture in the side of the air reservoir, as near as I can decide without measurement.
125

Q. On a large engine?

A. I am not positive about that point, but it appears to me to be so.

Q. In your opinion, sir, is the mode of tripping the valve represented in this model, as used in the engine of the defendants, substantially like, or substantially different from the mode of operation described in Sickels' patent?

(The defendants' counsel objected to this question, and it was ruled out by the court.)

Q. I will ask you whether, in your opinion, the combination of parts for lifting and tripping the valve in the de-
126 fendants' engine, is substantially like or substantially different from that described in Sickels' patent?

A. I think it is substantially the same. I can tell better by showing the parts.

Q. I will get you to point out from this model and the patent, why you deem them alike.

A. I premise about that point, that I do not think it makes any difference whether this unlatching gear makes a communication between the stem and the lifter at the point where it is now shown, or whether it unlatches the lifter attached to the stem from the outside rod. If this stem were rivetted to the lifter, and if the lifter were loose
127 upon the rod, and the unlatching apparatus were applied to a notch on the outside rod, instead of on the valve-stem, I should consider it to be substantially the same.

Q. Will you point out to the jury the combination, and the reason why you deem it substantially like the combination in the defendants' engine.

A. In the defendants' engine this horizontal rocking rod is a valve-stem, or a prolongation of the valve-stem. It is the agency through which this valve is moved. We have here another arm which is keyed fast to this valve-stem, and

we have here a rod which moves backward and forward 128
by its connection with the wrist-plate. At the end of this valve-stem or prolongation of the valve-stem, we have an arm keyed fast to it. From the wrist-plate or rocking-plate moved by the eccentric, proceeds another arm, which has a notch in it, and which can engage or disengage with a hook upon the arm, keyed fast to the prolongation of the valve-siem. There is also a spring underneath the arm, attached to the rocking-plate, which tends to keep the notch upon that rod in connection with the hook upon the arm of the valve-stem. The rod attached to the wrist-plate has, in this
particular engine, a compound motion. It moves in the 129
direction of its own length, and also in other directions perpendicular to its length. The hook and notch are kept in gear by a spring. At certain portions of the stroke, which is determined by the position of a stop, moved by a wedge upon a rod, the arm attached to the wrist-plate comes in contact with the end of that stop, and is thrown away from the hook on the rocking arm attached to the valve-stem, in such a manner as to break the connection between the valve and its moving mechanism. The reason why the arm at-
tached to the wrist-plate strikes that stop is because it has 130
a compound motion, which I before spoke of, so that the rod itself forms as it were an inclined plane, as it passes by this stop. The inclined plane might be measured between lines drawn from the notch to the wrist, when in one position, and from the notch to the wrist when in another position; so that that rod forms an inclined plane and strikes against this stop, which is actuated by the adjustable wedges. When the arm on the rock-shaft is detached from the mechanism
which moves the valve, a weight attached to another arm 131
upon that same prolongation of the valve-stem, causes the valve to cover its port, and cut off the steam. The slam is taken off that weight by its falling into the reservoir. As that weight falls, the air under it first passes out rapidly through the opening or hole in the side of this cylinder, which is underneath the bed-plate of the engine; and, as soon as the plunger and weight have passed that hole, the air has no means of escape, except between the outside of the plunger and the inside of the cylinder. The weight, there-
fore, as soon as it passes that hole, is arrested in its descent, 132
and brings the valve up suddenly at the proper point for closing the port. I will state, in this connection, the same as I stated in the other, with a view of showing upon what my views are based. Here is the hole by which this weight passes in its descent. You see that the weight passes by the hole in its descent. On the working engine it falls about three-eighths of an inch below the hole. The air escapes through the hole until the plunger passes it, and shuts it up;

Renwick

133 and after that the escape of air is between the outside of the plunger and the inside of the reservoir only. It makes no difference whether that hole be bored from the inside of the cylinder to the outside, or whether it be a groove, carried up in the inside of the cylinder—the air would pass out through that groove in precisely the same way, until the weight had fallen below the bottom of the groove and closed it. In Sickels' dash-pot you find that that hole is like a groove in the side of the cylinder, as shown in the large model. It is necessary to close these valves with considerable accuracy,
134 and in order to do that, there is in a working engine a contrivance which admits of an adjustment of the length of the rod between the rocking-arm and the plunger. If this rod were too long or too short, the engine, of course, then would work badly, but, by adjusting its length, the port can be closed accurately.

Q. Is it material, where an adjustment of that sort is required, whether you form the adjustment by shifting the distance between the plunger and the valve-stem, or by shifting the cup or air cylinder?

A. It makes no difference. If this air cylinder or air
135 reservoir, or air dash-pot, underneath, were set upon a screw, so that it could be lifted or lowered, and adjusted, it would have precisely the same effect as if the length of this rod which closes the valve were altered.

Q. What kind of valves were generally known at the time this patent was granted to Sickels, besides puppet valves?

(This question was objected to by the defendants' counsel and was ruled out by the court.)

The Court then adjourned to December 22d, 1854, at 11
136 o'clock A. M.

December 22d, 1854, 11 o'clock A. M.

The *direct examination* of Henry B. Renwick, a witness for the plaintiff, was resumed:

Q. In the working of rotating or sliding valves, is it important that the valve should move beyond the point which is necessary to close the port or aperture through which the steam passes?

137 A. It ought to move just far enough to cover the port, and no farther, when working as a cut-off, because if it moves past the port, force is required to bring it back again in opening the port, which would produce a consequent loss of power and motion.

Q. I will get you, sir, to describe to the jury what is the identity and the difference of operation and construction between the valve represented in the defendants' model, and that represented in the plaintiffs' model.

A. In defendants' model the steam is admitted into the 138
steam-chest through a pipe on the top of the steam-chest.
It flows in either direction through two passages, leading to
what may be called the valve-chambers. In each of these
valve-chambers there are two apertures, one connecting the
chamber with this prolongation of the steam-pipe, and the
other connecting the chamber with the interior of the cylin-
der. If the crank of the engine be placed in such a posi-
tion as it will assume after the steam has been cut off, the
valves in both those chambers will close the apertures that
lead to the cylinder; but when, by the revolution of the 139
crank, the piston has arrived at such a point that it is about
to change its motion, and it is necessary to admit steam
upon the other side of it, one of those valves then moves
from the aperture which leads into the cylinder, and permits
the steam to pass freely through this prolongation of the
steam-pipe into the cylinder, so as to cause it to commence to
move in the other direction. After it has moved a certain
distance in that direction for the required period of cut-off,
the valve is unlatched from its working mechanism, as I ex-
plained yesterday, and this weight causes the valve to return 140
backward, so that it covers that port again, and shuts the
hole, thus cutting off the communication between the steam
in the boiler and the steam in the cylinder. In order to
effect that cut-off, it is only necessary for this valve to drop
just so far as will enable it to cover the hole. If it drops
further than necessary to enable it to cover the hole, on the
next revolution of the engine this valve must be moved
backward. The valve, therefore, in this engine, acts as in
all engines with four valves, and serves only one purpose,
which is to open and close the aperture leading out of that 141
valve-chest into the cylinder. In the model of Mr. Sickels',
this opening on the opposite side from the outside of the
rod would be connected with the steam in the cylinder,
and is technically termed a nozzle. The steam enters into
this steam-chest through a pipe attached thereto. By a pe-
culiar arrangment in that chest, the steam lies on the top of
the upper valve, and below the lower valve; and, when the
valve closes the port, which is the present position of the
model, the steam cannot enter into the cylinder. When
the valves are open the apertures leading into the nozzle 142
from the steam-chest are open, and the steam passes through
the ports, and through the nozzle, into the cylinder. When
the proper period for cut-off arrives, this valve is unlatched
from the lifter, and the valve closes the port, and permits
the steam to act by its expansive force only upon the piston,
during the rest of the stroke.

Q. Explain to the jury in what way the valve in the
plaintiffs' model can be constructed, so as to avoid the ne-

Renwick

143 cessity of accurate adjustment between the seat of that valve and the plunger in the dash-pot, which you have stated would be the same as allowing this valve to move farther than is necessary to close the port?

A. In one manner in which this double-beat puppet valve is employed, there is no necessity for any change in its construction, because it has been found that in some cases it is advantageous to key the valve fast on the lifter, so that it cannot revolve, and to let it seat itself with a slight jar, thereby tending to draw the conical portion of
144 the valve into the conical portion of the seat, and make it tighten itself at every blow. The jar, of course, must be graduated with nicety. In other cases, what is technically termed a check-ring, which is a small portion of a cylinder, is bolted on to the upper and under side of the nozzle, and the inside of that cylinder is ground out to precisely the same size as the outside of the valve. In that case, the valve closes its port before the conical part of the valve strikes its conical seat.

Q. In that case, sir, would it result in a loss of power, as
145 in the case of the rotating valve moving farther than is necessary to close the hole?

A. In ordinary puppet valves, not balanced, it would result in a much greater loss of power; and in puppet valves as balanced, it would depend upon the nicety of the balance; but there would always be a loss

Q. Explain what you mean by a balanced valve.

A. In my explanation before, I stated that the steam was above the upper valve, and below the under valve. If, now, I were to cut one of these valves off its seat (referring to
146 model) and nail it fast over the port, permitting the other valve to play as it does—suppose we nail the lower one—when the upper valve was lifted, the steam would pass downwards through this port into the nozzle, and consequently into the cylinder, just in the same manner as it would if it lifted both valves. But, in that case, the upper valve would be pressed upon by a force equal to its area multiplied by the pressure of the steam in the boiler; and when a person commenced working an engine by hand, it would have to overcome that weight, at the instant of open-
147 ing the valve, at every stroke, and consequently so much power would be lost. Then, in order to obviate that, the lower valve was bolted upon the same stem as the upper valve, and the steam was permitted to pass beneath it. Consequently, when the valve is closed, the steam presses upwards on the lower valve, and downwards on the upper valve. If the area of the two valves were equal, no force would be required but just sufficient to lift them. But, in that case, a slight jar would be apt to throw the valve up at an improper time, or it would, perhaps, not

close itself to its seat. For that reason, the lower valve 148
is made slightly smaller in diameter than the upper valve, so that there is not so many pounds pressure upon the lower valve as upon the upper one, and there is a slight tendency to keep the valves in their seats. That tendency depends upon the amount of the pressure of steam, and upon the size of the ring which you would make by punching a smaller valve out of the larger one.

Q. Will you explain to the jury what is understood by balanced valves, as applied either to rotating or sliding valves?

A. The ordinary sliding valve is a valve which slides 149
over a port as my hand slides over this piece of board (illustrating it). The steam is admitted upon the top of the valve, and of course presses that valve upon its seat. (Witness explained on the model, and said there were various other ways of balancing the valve, which he was unable to illustrate without a diagram.)

Q. Will the pressure of the steam in the valves of the defendants' engine be balanced?

A. So far as I can judge from this model, the valve itself,
in this case, appears to be capable of slight motion in the 150
direction of the perpendicular to its stem, upon the piece of iron which is here inserted. In that case, the steam, when this valve was shut, and the piston was travelling in a direction towards me, would press upon this part of the valve, and hold it firmly down upon its seat.

Q. Resulting in a waste of power necessary to overcome that pressure?

A. If the valve were fastened rigidly to that stem, it would have no provision for wear, and, after working, it would be apt to make the stem lock.

Q. Yesterday you told us that you found in the defend- 151
ants' engine substantially the same combination which is found in Sickels' patent. Will you give your reasons why, in your judgment, the combination is substantially the same?

A. I find in both engines a valve-stem, communicating with a valve; I find in Sickels' what is technically called a lifter, and in the defendants' engine a rod upon the rock-shaft arm, which is equivalent to the lifter; and I find, in order to communicate motion to the valve, an arm or rod
having a reciprocating motion. I find that that arm is locked 152
fast to the lifter, in Corliss' machine, when it is necessary to open the valve, and when it is time for the valve to close, that that connection is broken. I find that it depends for that action of making and breaking the connection upon a spring catch or latch; and I find in both engines an adjustable stop for regulating the period when that catch shall

Renwick

153 be unlatched, in order to permit the valve to close its port.
I do not know that it is necessary to point out again
the same parts in the Sickels engine. I find that the
valve in this (Corliss') engine is brought to its seat by
a weight ultimately attached to the stem. I find that in
Sickels' engine the valve is brought to its seat by its own
weight, attached to the stem, and by the weight of the
plunger attached thereto. I find in both instances that that
plunger passes freely in a reservoir where there is an escape
of fluid from one side to the other, and that it after-
154 wards gets into a part of the reservoir where the escape is
very much contracted, and which contracted portion of the
escape is so placed that it shall close the valve with some
tolerable suddenness—arrest its motion promptly.

Q. When you saw the defendants' engine at work, did
you find, upon the descent of this weight which closes the
valve, any rebound?

A. I found none. I directed my attention carefully to
that point. I placed my hand upon the small rod which
connects the valve with the plunger, and found that it de-
155 scended rapidly at first, was then checked, and descended a
little farther very slowly; but I could not perceive any
rebound at all.

Q. Now, as a matter of mechanics, so far as regards any
injury to the valve and its connection with the seat, is there
any material difference between stopping the valve, by
allowing the weight connected with it, and which weight
closes the valve, to be arrested suddenly by striking a solid
body, or letting the valve itself strike a solid body?

A. The jars would be the same in both instances. There
156 is a difference of opinion among engineers with regard to
the fact of the slight slam at the moment of closing. Some
engineers think that a slight slam in puppet valves, at the
moment of closing, is advantageous, and others say that it
is hurtful.

Q. Now, sir, with reference to the arrangement in the
defendants' model, if the weight which causes the valve to
close suddenly were to be suddenly checked by falling upon
the bed-plate of the machine, what would result from
that?

157 A. It would impart jars and vibrations to the whole
machine, and also a sudden rocking motion to the valve
upon its seat, which would not do the valve or seat very
much good.

Q. As a question of practical mechanics, if I allowed a
rod of iron to come down suddenly and strike a heavy blow,
is the injury to that piece of iron confined to the place
which comes in contact, or does it affect every part of the
rod throughout its entire length?

A. It affects strictly the whole of the rod. 158

Q. Do you know of any examples in engineering where it has been manifested?

A. It is manifested most particularly in the axles of rail-road cars, where, although the jar is entirely upon the wheel, we find that the axle rapidly deteriorates from the jars which it receives, and becomes weaker and weaker every day.

Q. Are you familiar with the Nasmyth steam-hammer?

A. Tolerably so; but that patent is based upon the contrivance of a spring so placed as to obviate in some degree 159
the effect of the jar upon the rod.

Q. You have stated, sir, that in the opinion of some engineers a slight slam when the puppet valve reaches its seat, is of advantage. Now, would the slam which the valve would receive, if not checked by the dash-pot, be such a slam as you have reference to?

A. No, sir, it would be too great. If the valve were not checked by the dash-pot, probably it would fall through its seat, in an engine of any size.

Q. In puppet-valves, is there any danger of the valve 160
rebounding when it closes?

A. Rebounding from its seat?

Q. Suppose, in using the dash-pot described in Sickels' patent, if air were used instead of water, would there be any danger of the valve rebounding by reason of the elasticity of the air?

A. I think none. As I stated before, both in the double-beat or balanced valve, and in the single valve, there is a pressure of steam tending to keep the valve upon its seat, whenever the valve is down, and the pressure in the boiler is greater than the pressure in the cylinder. Now, if the valve be 161
brought very near to its seat, without actually touching it, it checks the flow of steam from the boiler into the cylinder, and in that way diminishes the pressure of the steam on the cylinder side of the valve. The instant the pressure of the steam is diminished upon the cylinder side of the valve, there is a tendency for the steam to seat the valve into its seat, and if the valve were checked just before it reached its seat, or even bounced up when it reached its seat, the pressure of the steam would shut it and hold it tight. 162

Q. In your judgment, do you see any difficulty in substituting air or other gasses for water in the Sickels' dash-pot?

A. I see no difficulty, except that it would require some experiments to determine the size of the dash-pot, and the size of the passage for the air to pass from one side of the cylinder to the other; just in the same way as it did to determine experimentally the size of the dash-pot and the

163 size of the passage when it was attempted to employ water.

Q. The graduation would have to depend upon the density of the fluid used?

A. Yes.

Q. I will ask you whether water is perfectly non-elastic, or whether it is elastic?

A. Water is well-known to be slightly elastic.

Mr. Blatchford.—Q. Pure water?

A. I do not know where you will find pure water. In the experiment made by Professor Henry, he used perfectly
164 pure water—at least as pure as he could make it by the nicest chemical tests—and he found that he was able to compress the water sensibly; and therefore, of course, water is elastic.

Mr. Keller.—Both in Sickels' dash-pot and in the dash-pot used by the defendants, is or not the aperture for the escape of the fluid gradually contracted by the descent of the plunger?

A. On the model it is not shown.

Q. Then take it as described in the patent.

165 A. As the plunger descends in Mr. Sickels' dash-pot, the fluid which he employs can escape from the one side of the plunger to the other, through an aperture the size of which is measured by the ring which could be placed between the outside of the plunger and the inside of the reservoir. As the plunger descends towards the smaller part of the reservoir below, there will arrive a time when the ring between the upper edge of the contracted part of the reservoir and the lower part of the plunger will be of less area than the ring between the outer edge of the plunger and the inner
166 side of the reservoir. As it descends, that space will gradually contract, until the plunger barely enters into the small part of the dash-pot, and the water then can escape only through a very small space between the outer circle of the plunger and the inner periphery of the contracted part of the dash-pot.

Q. Now, with reference to the defendants' model?

A. As this plunger descends, the air passes out freely through this aperture, which we have here, (illustrating on defendants' model) until the bottom of the plunger gets to
167 the top of the aperture. The plunger then commences to close the aperture gradually, and, after the bottom of the plunger has passed the lower part of the aperture, the air then can only escape through the narrow space between the outer periphery of the plunger and the inner side of the dash-pot.

The Court.—Can you determine whether the inner bore of the defendants' dash-pot diminishes towards the bottom?

A. The bore in the defendants' dash-pot does not diminish. The stopping of the plunger is caused by the pressure of the air, after the plunger has passed and closed the aperture. 168

Mr. Jenckes.—Are the piston and cylinder entirely cylindrical from top to bottom, or is there a contraction below the aperture?

A. The defendants' cylinder is bored out the same size throughout.

Mr. Keller.—In other words, do you find in the defendants' dash-pot an equivalent for the reduced diameter of 169
the reservoir into which the plunger enters in Sickels' dash-pot, at the time that it brings up the valve?

A. I do; that is, the hole passing through the side, which admits of the free escape of air from the one side of the plunger to the other, until the plunger has passed that hole.

Q. When the plunger, in Sickels' dash-pot, enters the lower reservoir, and has gone entirely into it, is there any more space between the outer circumference of the plunger and the inner circumference of the cup, than there is between the inner circumference of the cylinder and the outer 170
circumference of the plunger in the defendants'?

A. I think in a practical machine that the fit is not quite so tight in Sickels' as in the cylinder of the defendants', because the fluids used in the former cannot pass through a small hole so rapidly as the air used in the latter.

Q. Looking at the dash-pot of the defendants', and the description of the dash-pot in Sickels' patent, do you find any means in the defendants' dash-pot of relieving the pressure of the air at the time of lifting the plunger?

A. I find in the bottom of the defendants' dash-pot a 171
small valve opening upwards. When the plunger commences to rise, after it has passed the small hole, it will of course make a partial vacuum under the plunger.

(Witness described on defendants' model, and explained how the air entered through the small valve underneath the plunger.)

Q. Do you find anything in Sickels' patent to relieve that pressure, at the time of lifting the plunger?

A. I do. I find in Sickels' patent that there is described
a small valve underneath the plunger, and upon the same 172
stem by which the plunger is carried. I also find that there are holes bored through the plunger.

Mr. Jenckes.—Through the top?

A. All the way through. As the plunger descends, this valve rises and closes those holes, so that no water can pass through them, but so that all the fluid must pass around the edges of the plunger. After the plunger has seated itself in the small part of the reservoir below, and com-

Renwick

173 mences to ascend, this little valve will drop, and the water will pass through these holes, so as to arrive under the plunger and thereby prevent the formation of a partial vacuum under the plunger when you lift it, and the loss of power that would be consequent upon that partial vacuum below the plunger.

Q. With a view to relieve that pressure of the lifting of the plunger, does it constitute a substantial difference whether the valve be in the bottom of the cylinder or in the plunger itself?

174 A. It makes no difference that I can perceive. The valve opening downwards in Sickels' plunger would have the same effect as the valve opening in the bottom of defendants' cylinder.

Q. Did I understand you to state, yesterday, whether in the engine used by the defendants you found a means of regulating or adjusting the position of the plunger relatively to the position of the valve?

A. I found the means of regulating, so far as I could discover from the examination that I made, the length of this
175 rod, and regulating this rod would, of course, regulate the distance between the bottom of the plunger and the face of the valve, and would regulate the relative distance between the valve and the small part of the dash-pot.

Q. Is that substantially like, or substantially different from the mode of regulation described in Sickels' patent?

A. As I said yesterday, I do not see that there would be any difference in raising or lowering this small dash-pot, or altering the length of the rod which supports the plunger that falls into it.

176 On being *cross-examined* by Mr. Jenckes, one of the counsel for the defendants, the witness Henry B. Renwick, testified as follows:—

Q. Will you look at this model (handing witness a mahogany model of both of the apparatus described in Sickels' patent) and examine it in connection with the drawings of Sickels' specification, and state how it compares with them?

A. The plunger here is a little out of order, and requires
177 adjustment. With that exception, it appears similar to the black model produced, except that the dash-pot is here shown in section.

Q. Point out the parts of the dash-pot to the jury, as shown in that section?

A. The part of the dash-pot where the plunger descends rapidly, the water passing freely from one side of the plunger to the other, is shown in this model. The contracted part of the dash-pot, where the water passes with

difficulty, and the passage is very much contracted, is this 178
cup or secondary reservoir, which rests upon a screw passing through the bottom of the dash-pot. The valve, which I explained as shutting upon the downward passage, is represented by this white piece of wood, and you will perceive the holes in the plunger, through which the water may pass during the upward motion of the plunger, so as to prevent a partial vacuum, after the plunger has fallen into the small part of the dash-pot.

Q. Is that an accurate representation of those parts?

A. It is accurate enough for representation, though the 179
parts are not so accurately adjusted as to work.

Q. In both those models of Sickels' machine, have you not a lifter in the common form of lifter described?

A. If you will state what you mean by the lifter, I will answer your question. Engineers call it by different names.

Q. I refer to *that*. Is not *that* a part of the valve-gearing, as we commonly see it on steamboats?

A. No; many are arranged without it.

Q. As we commonly see it? 180

A. All the marine engines now built by the Novelty Works, are without them.

Q. Without this valve-gear?

A. Without lifters.

Q. I speak of the lifter as part of the valve-gear?

A. Many of them are made without.

Q. Ten or twelve years ago, how was it?

A. Watt made his engines without it.

Q. In 1841 or 1842, what was the common valve-gearing used? 181

A. The most ordinary valve-gearing had that form of lifter.

Q. As the puppet-valve was then used, was it in the form also represented upon the model? Was that the common mode of constructing puppet-valve-gearing?

A. Do you mean the valve or the gear?

Q. The valve, and the valve-stem; the connection with the lifter, and the lifter?

A. That was then an uncommon mode of making puppet-valves; I think there were more unbalanced valves used at
that time than balanced valves. 182

Q. In other particulars than that?

A. In the particulars of the gearing, this outside rod, lifter and valve-stem, are as ordinarily employed.

Q. I am referring to the valve-gearing. The balanced valve was known before that time. Was it not then in common use?

A. It was in use.

Renwick

183 Q. The mode of working both single valves and balanced valves, was as represented in that model?

A. Not exactly; because the single valve-gearing has a hollow stem, and one lifter works over the other,—an in-and-out arrangement, which looks very different from this.

Q. That model represents, as you have explained, the balanced valve?

A. Yes.

Q. Portions of that valve-gearing, lifter, valve-stem and
184 the valve itself, all move in right lines, do they not?

A. As nearly as they can be got to do so; but the outside lifter never can be made to move in a right line.

Q. It moves through guides?

A. Yes; and as near as the guides can keep it, it moves in a straight line; but it always vibrates.

Q. They move also in parallel lines?

A. The stem and the lifting rod do.

Q. And the valve, of course, partakes of the motion of the stem?

185 A. Yes.

Q. In both the models of Sickels' patent before you, the valve-stem is a piece of metal that passes through the valve?

A. No; it commonly terminates at the upper valve *here*, (illustrating.)

Q. It is continued through both valves?

A. Yes.

Q. You give the name of valve-stem to the upper
186 part?

A. Yes.

Q. When the valve-stem is referred to, in the description of this model, and in the specification, it refers to the spindle above the upper valve?

A. The spindle by which the valve is actuated, and that portion above the upper valve, I would call a prolongation of the valve-stem.

Q. Will you examine how this valve-gear, which is represented in Sickels' model; is moved; how motion is
187 imparted to this lifter, and through it to the valve-stem and the valve?

A. Motion is imparted to that lifter in various ways,—but the usual method is by a rocking shaft, which occupies a position below the lifting-rod, which has a toe upon it which acts upon a foot upon the lifter. (Witness explained on the model.)

Q. How is motion imparted to the toe?

A. Through the eccentric.

Q. The kind of valve-gear you have described, is that referred to in this specification? 188

A. I do not know, because I do not think Sickels describes any way in which motion is given to this outside rod.

Q. The language is, "in the usual way?"

A. That would be an unusual way.

Q. Would it not be the most usual way, when this specification was drawn?

A. The most usual way in steamboat engines; but not in any other engines. 189

Q. This form of steam-chest was most usual in steamboat engines?

A. Yes.

Q. And a steamboat engine is delineated in the drawing?

A. I do not so understand it; all engines are not made exactly alike.

Q. Turning to Mr. Corliss' model, do you find the lifter in this form?

A. I find an arm attached to the valve-stem, by which 190 the valve is moved.

Q. Will you answer the question?

A. Will you define what you mean by "form?"

Q. As defined in this model, the form of drawing in which this model was made. Do you find the lifter in Corliss' engine, made in the form represented here?

A. No; this lifter here is square, and the other round?

Q. This lifter in Sickels' is part of a combination for working the valve? 191

A. Yes.

Q. It has a form, as a part of that combination?

A. Yes.

Q. A form that was used in 1841 or 1842?

A. Yes.

Q. Do you find the form of lifter in Corliss' model?

A. I find a lifter, not in the same form.

Q. Do you find that lifter in a different form in Corliss' engine from what it is in Sickels'?

A. Yes. 192

Q. Do you find a valve-stem in Corliss' model, passing through the valve and moving it in the way in which Corliss' valve is moved?

A. Sickels' moves in the direction of its own length; Corliss' oscillates upon its own axis.

Q. Do they move in the same way?

A. Of course, they do not.

Q. Then their motion is different?

A. Yes.

Renwick

193 Q. Do you find the valve-gearing, which is represented in Sickels' engine, lifter, valve-stem and connection between the valve-stem and the lifter, in the same forms in Corliss'?

A. Not precisely in the same forms?

Q. Do you not, upon Corliss' model, find a different form of valve-stem,—a substantially different form of valve-gearing?

194 A. No; they are substantially the same for the effects which they are calculated to produce.

Q. You say they are substantially the same?

A. Yes.

Q. In the mode in which they operate?

A. As near as I can tell, Mr. Corliss' lifter moves backwards and forwards, and Sickels' lifter moves upwards and and downwards.

195 Q. I understood you to name the arm which connects with the rod passing through the valve, in Corliss,' as the lifter?

A. Yes.

Q. And this arm, connecting with the wrist-plate, as the lifting-rod?

A. Yes; I said that this arm keyed upon the valve-stem, is called a lifter in Sickels' machine; and that arm which
196 makes a connection between the valve-stem and the lifting-rod, is what is called a lifter in Corliss' machine.

Q. Do you limit the term lifter to any portion of that connection?

A. Yes; the horizontal portion.

Q. Do you find in Corliss' machine the eccentric moving the lifter, or the lifting-rod, through the toes on the rock-shaft delineated in Sickels'?

197 A. No; but I find the eccentric moving the lifting-rod.

Q. There is no substantial difference between the two in the mode of operation?

A. Not for the purposes here wanted.

Q. In the mode of operation?

A. As far as the opening and shutting of the valve is concerned, I see no substantial difference.

Q. Do you move the valve in Corliss' machine at the same point that you move the toes of the rock-shaft in
198 Sickels' machine?

A. No, sir.

Q. Do you call the shaft that modifies the motion of the eccentric a rock-shaft?

A. It does not modify it; the rock-shaft vibrates upon its axis.

Q. And for that reason it is called a rock-shaft?

A. Yes.

Q. Does this rod in Corliss' machine, which passes

through the valve, have another motion than the rock-shaft? 198

A. No; it is the same, except in distance.

Q. There is no need, in Corliss' machine, of this contrivance by which motion is communicated beyond this secondary rock-shaft to the valve?

A. No, sir; there is no need of it in that machine.

Q. I inquire whether the contrivances which you have named—the lifter, lifting-rod, valve-stem, toes of the rock-shaft, and toes of the lifter—are to be found, as a matter of fact, in the defendants' machine?

[The witness explained and illustrated upon the model, 199
the action of the various parts of the valve-gearing in Sickels' machine, and pointed out what he called the "equivalent mechanism" in Corliss' machine. The names of these parts, he said, depended upon the offices they performed.]

Q. You give different names to all these parts?

A. Yes; according to the offices which they perform.

Q. In the Sickels' machine is there a spring upon the lifter?

A. Yes; there is. 200

Q. What office is performed by that spring?

A. That spring latches the valve-stem fast to the lifter.

Q. Does it perform any other office?

A. And unlatches it.

Q. Any other?

A. Not that I know of.

Q. Upon what does the weight of the valve rest?

A. Upon that spring; not upon the spring, but upon the piece of iron fast to it.

Q. Then what is attached to the spring aids in lifting the valve? 201

A. It makes the connection between the valve-stem and the lifter; it does not aid in lifting it.

Q. Is it not necessary that the spring, or the parts attached to it, should pass through the notch in the valve-stem?

A. I do not understand you; they pass into the notch.

Q. And come out the other side?

A. Yes.

Q. Is it not necessary, in that model, that it should be so?

A. Yes.

Q. This is the proper construction indicated in the drawing? 202

A. Yes.

Q. Do you find any spring upon the defendants' model which performs any such office as that?

A. It is pretty well put away, sir; that spring (pointing it out) keeps the lifting-rod in connection with the lifter.

Q. At any portion of the operation of that valve-gearing

203 is there any force exerted by this spring to open the valve, or does the valve operate as in Sickels'?

A. No.

Q. At any portion of its operation, does the valve rest against the spring?

A. No.

Q. The spring does not aid in opening the valve in Corliss' machine?

A. No, nor does it in the Sickels machine; it connects the parts; if you were to take that spring out (pointing to
204 Corliss' machine) that lifting-rod would never move that valve.

Q. Does the weight of the valve rest upon the spring in any way?

A. It does not.

Q. Is there an adjustable sliding-piece in Sickels' model?

A. Here it is (pointing it out.)

Q. It may be taken off and reversed?

A. Yes.

Q. What would be the effect of that upon the point of cut-off?

A. It would cut off before and after half-stroke.

205 Q. Would Corliss' engine cut off beyond half-stroke?

A. I do not think this one here would cut off beyond half-stroke; I am not exactly certain, for I have made no exact calculations.

Q. Point out the adjustable sliding-piece?

A. This piece with wedges, in connection with these two little wedges, makes an adjustable sliding-piece, which determines the point at which the engine should cut off.

Q. Where do you find in Corliss' the adjustable sliding-piece, its wedges, and inclined planes?

206 A. I find that in two places; I find that this long black rod, which moves backward and forward by a motion derived from the governor, has two wedges upon it, which regulate the position of two sliding pieces, one for each valve, which, in this (Corliss') model, are represented as moving in a perpendicular direction; I said yesterday that what I termed the lifter has a compound motion—one in the direction of its own length and the other perpendicular
207 to its own length, and that it of itself forms an inclined plane, the angle formed by which inclined plane might be measured between two lines, one drawn from the wrist in one position to the hook on the lifting-rod, and the other drawn from the wrist in another position to the hook on the lifting-rod, and that that motion, in connection with this long black rod and those sliders make the adjustable stop by which the engine is permitted to drop the valve.

Q. It is moving continually when cut off, in a direction from the valve, is it not? 208
A. Yes.
Q. It rises into an inclined position before it effects the cut-off?
A. Yes, (describing it.)
Q. It is moving in a direction from the valve-stem?
A. Yes.
Q. When it rises into an inclined position, do you find the inclined plane in that position?
A. Yes.
Q. And you say that the motion which it then derives and which effects the cut-off, is the same as the action of the wedges in Sickels' machine?
A. Substantially the same. 209
Q. For a wedge to act, it must move in the direction of its apex, or something must impinge against it?
A. Yes.
Q. When Corliss' effects the cut-off, is it not moving in an opposite direction from its apex?
A. Yes.
Q. In order to act as a wedge, it must be moving in the direction of its apex or point?
A. No; not always; for in Corliss' machine, we find one which is cut off in another direction.
Q. Well, then, in Corliss' machine, it does not act as a wedge?
A. It does not act as a wedge.
Q. The three things to be found in Sickels' machine are: the valve-stem, the spring upon the lifter, and the adjustable sliding-piece, with its wedges? 210
A. Yes.
Q. What do you understand by the "immediate appendages" spoken of in the plaintiffs' specification?
A. I suppose he means the valve-stem, the lifter, the standard and the screw. I cannot say precisely what parts he means.
Q. Do you, as an expert, mean to say that you do not understand what he means by that?
A. I would say it is entirely immaterial.
Q. The claim is such that you cannot give a meaning, to satisfy yourself, of those words? 211
A. Yes; nor do I think it necessary to satisfy myself as to it.
Q. You think it was unnecessary?
A. I do not say that.
Q. Then we may presume these words were necessary. Do you think they have any meaning at all?
A. He meant some of these immediate appendages, but which ones I cannot state.

Renwick

212 Q. You cannot tell from the language of the patent?

A. I cannot state what would come within the phrase. I am not able to define precisely what those immediate appendages are.

Q. Define as well as you can?

A. (Referring to the specification.) As he states here, he puts into the claim, "the valve-stem B, the spring F upon the lifter, the adjustable sliding-piece I, with its wedges or inclined planes, and their immediate appendages." He leaves out the lifter itself, which is necessary, and he does not name the manner in which this sliding-
213 piece is supported; and I should suppose that the most reasonable supposition was, that he meant the lifter and the support of the adjustable sliding-piece.

Q. Does he name the standard?

A. I do not think he names the standard in the claim. He names the set-screw, because he says, "the adjustable sliding-piece, with its inclined planes."

Q. The adjustable sliding-piece includes the set-screw?

A. I think it probable.

Q. Do you find a standard in Corliss' machine?

A. I find a support for the sliding-piece.

214 Q. You were pointing out the equivalents to the sliding-piece, and the immediate appendages on Corliss' machine?

A. I was pointing out the equivalent to the standard—this rectangular piece of wood with slides in it, which supports this long bar with wedges on it, and the brass slides which rise and fall at the very period of cutting off. I do not see any set-screw here, or any equivalent for it.

Q. In the model of Sickels' improvement, what is the office of the water reservoir, or the dash-pot, as it is commonly called?

A. To check the valve before it arrives at its seat.

Q. Is that all?

215 A. That is all.

Q. Simply to check the descent of the valve?

A. To check the descent of the valve before it arrives at the covering of the port.

Q. Does it perform any other office?

A. I do not know of any other. There are results dependent upon that checking of the valve, but its immediate office is to check the descent of the valve, and to arrest it just before it closes its port.

Q. A cup, or secondary reservoir, is represented in that model?

A. That is where the descent of the plunger is checked at the proper time.

Q. It is described as adjustable. What is the object of having it adjustable?

A. To adjust it to the proper position of the port, so that 216
the valve shall be arrested at the proper moment.

Q. Is it necessary to alter that adjustment in the working of the engine?

A. Not often.

Q. At any time?

A. It is very seldom indeed altered. I have seen them working perfectly well for years without any adjustment.

Q. Do you consider this adjustability as necessary?

A. It is in some respects necessary. When you first put
an engine up, you cannot tell how fast the valve is going to
fall, and you must adjust the reservoir until you get it in a 217
condition to work the engine.

Q. Suppose you vary the point of cut off, is there any necessity to vary this cup?

A. I should conceive not, in practice; there might be, but I do not think it; the mere varying of the point of cut off does not require it.

Q. The distance through which the valve falls varies with the point of cut off?

A. Yes; I do not think it is necessary to adjust the cup;
I have never known any case, in practice, where they ad-
justed it for altering the point of cut-off; it might be, that 218
when you had it just properly seated to cut off at one-half
stroke, and you required to cut off at one-eighth stroke,
there would be a necessity, from some peculiarity in the
fluid, or other cause, to adjust it.

Q. Suppose it was necessary?

A. Then I would adjust it, if it was necessary.

Q. Does the adjustability have any reference to such a case as that?

A. I suppose it is adjustable for all causes where needed.

Q. Suppose you increase the pressure of the steam, would you adjust it then?

A. Not within any moderate limits; if you carried steam
up to 100 lbs., from an engine working 15 lbs., you might 219
have to adjust it.

Q. Do you consider the adjustability of any consequence, then?

A. I do.

Q. And it is valuable after the first adjustment of the engine?

A. Yes.

Q. You have seen engines where there was no adjustability?

A. I think I have.

Q. Do you find any adjustability in Corliss' machine?

A. Not upon that model; but I found it upon the engine; I found an adjustment between the plunger and the arm upon the valve-stem, to which the plunger is attached;

Renwick

220 I did not examine further, but I found there was an adjustment there.

Q. Did you look at other connecting parts of the engine?

A. No.

Q. Do you not know the fact, that there is an adjustment on the other connecting parts?

A. Not such an adjustment as there, (between the plunger and the arm of the valve-stem to which it is attached); the rock-shafts are adjusted by keys in the stem; in addition, there was a screw on the bottom, between this rod and the arm, which I conceive was there for that pur-
221 pose.

Q. Had that machine been used?

A. I suppose it had.

Q. Can you conceive any case in which it would be necessary to alter that adjustment in that engine?

A. In case they put a new dash-pot into that engine, and it was rather stiff, or the plunger struck the bottom of the dash-pot, it would, of course, be necessary to shorten the rod.

Q. Can you conceive a case where it would be necessary
222 to adjust it more than once?

A. The mere working of the engine would cause a wearing of the parts, which might require an adjustment.

Q. Suppose the parts should become changed in condition?

A. If the rod became longer, and the valve, when it fell, not able to cover its port, in that case it would be necessary to shorten the rod; the parts are all wearing, and are continually changing their distance; the principal reason why I conceive the adjustment necessary is, that it is built
223 and placed on the engine; I suppose it was put there for some good purpose, and my own convictions agree with that supposition; suppose that the rod were so long that the valve would not quite seat itself, I can suppose that it would require adjustment; it would not run well if not so adjusted.

Q. Suppose you have set up your engine, and adjusted those parts, can you conceive circumstances to alter that adjustment?

A. I can; a good many; there is a wearing of the different parts all the time; the bed-plate may, probably, be
224 sprung; these connections in the rod are varying, and a great many other different causes exist; in order, therefore, to make the engine work properly, it would be convenient to adjust that rod.

Q. You refer to the wearing of the engine—not to any changing from high to low steam?

A. That might be so.

Q. Do you suppose that the change from high steam to low steam would alter the distance that the weight descends?

A. Yes. 225

Q. Would it be good workmanship to have a weight so light?

A. Generally speaking, they do not calculate engines for an extraordinary change of steam; it would probably not occur in the usual working of an engine.

Q. State a case in which it probably would occur.

A. I have stated cases.

Q. Those you admit are extraordinary cases?

A. The wear of the parts is an ordinary case.

Q. When the weight falls, in Corliss' engine, does not the valve lap over its port? 226

A. It laps, certainly.

Q. When the weight and rod with which it is connected to the valve are adjusted, so as to close that port to a proper distance, is it not then suited to all conditions of steam in that engine?

A. Yes; throwing out the wear of the engine.

Q. Then, when it is once adjusted, at the starting of the engine, it is adjusted to all the ordinary circumstances of the use of that engine?

A. Except the wear of the engine.

Q. All except the wear?

A. Yes. 227

Q. That takes place, gradually, in the parts?

A. Generally speaking.

Q. Nothing short of some external violence could change it suddenly?

A. It generally takes place gradually.

Q. Could not the original adjustment of this weight have reference to the ordinary wear of the engine?

A. No.

Q. Could it not be adjusted with reference to the ordinary wear, for a period of one, two or three years?

A. No.

Q. The causes that you have given are entirely probabilities? 228

A. Yes.

Q. Do you know of any causes that would require the alteration of that adjustment specially?

A. I suppose there are causes which would require the alteration of the length of the rod.

Q. If the point of cut off is varied, in Corliss' machine, would it become necessary to adjust the position of this weight?

A. It might be, and might not.

Q. What is your opinion? Can you conceive a time when it is necessary?

A. It might be necessary.

229 Q. Will you describe the circumstances under which you suppose that necessity to exist, in connection with the point of cut off?

A. When it was raised a very little way, cutting off very short with a given amount of steam, the plunger would have very little distance to fall, and it would acquire little velocity before it struck the inner parts of the dash-pot, and it might, in passing through the inner part of the dash-pot, drop so slowly as to wire-draw steam; whereas, if it were raised higher it would cut it off in the proper way.

Q. What distance does that weight traverse in an ordinary engine?

230 A. Different distances.

Q. Within what space?

A. I think, in the engine at Youngs & Cutter's, the weight travels some six or eight inches.

Q. Did you notice whether steam was cut off short or not?

A. No; and even if I had, I could not tell whether the valve was doing its duty or not.

Q. Can you conceive a weight being so out of proportion to the engine that it might affect it?

A. Yes.

Q. Can you conceive the case of a well-constructed engine of that kind?
231

A. Yes; I never knew an engine yet that was perfect.

Q. In the Sickels' model the descent of the valve is checked just before closing—that is the object of the reservoir?

A. Yes.

Q. Do you find that operation in Corliss' machine?

A. It is, as near as I could decide, from looking at the engine.

Q. In Sickels' machine it must be checked just before the closing of the valve?

A. Yes.

232 Q. When puppet-valves are used, it is so invariably?

A. Except a puppet-valve with a check-ring; with a common balance check-ring it might be checked some time before closing the port.

Q. As described in Sickels' model?

A. It must be checked prior to the instant of closing.

Q. And the checking must take place, in all cases, before it comes to its seat, in that model?

A. Yes.

Q. It cannot be checked after the valve comes to its seat?

A. No.

Q. Do you find the same effect in Corliss' engine—

checking and closing of the valve, just before reaching its 233
seat?

A. In Corliss' model, it seems to be checked just after the valve covers its port.

Q. It is checked just after it is closed?

A. It checks just at the instant it is closed; just at the moment of cut off.

Q. It is not checked before the valve is closed?

A. No; just at the moment of closing.

Q. You have stated that it was desirable to close the valves as quickly as possible?

A. Yes.

Q. "Lightning speed," I believe those were your words, 234
or as near as you can get to it?

A. Yes, speaking theoretically.

Q. In Corliss' engine, you have the advantage of that speed, have you not?

A. That depends upon how large the weight is, and how fast it drops.

Q. If you put a spring upon the weight, you have additional speed?

A. Yes.

Q. Can you have it in Sickels' machine?

A. As fast as the weight will carry it.

Q. Clear up to the time of actual closing?

A. Just before. 235

Q. And the space of time between the checking of the rapid descent of the valve and its resting upon its seat; what is that?

A. It would be an imperceptible portion of time.

Q. During that period of time the steam would be wire-drawing between the valve and its seat?

A. If the steam could get through in that time.

Q. But some would?

A. Not enough to make a difference.

Q. Can you not tell by an indicator?

A. I do not believe you could measure it; I think it would be immeasurable; I have never seen the indicator applied to Sickels' machine, but I have seen people who
have tried it. 236

Q. Have you ever seen the indicator applied to Corliss' engine?

A. I have not.

Q. Have you ever seen the Sickels cut-off in operation, with any other liquid than water in the dash-pot?

A. Yes.

Q. What other?

A. At least I have been told that other liquids were in the dash-pot, but I did not examine it; some people use

237 molasses, some soap-suds, and some use a mixture of molasses and water.

Q. Did you ever know of alcohol being used?

A. I do not know; it might have been.

Q. Is that contrivance, (Sickels',) as it stands, adapted to the use of any other fluid than water?

A. If you were to change its proportions, it would be.

Q. As described in the specification?

A. The description does not give its proportions; it does not define any proportions.

Q. As delineated in the drawing?

A. That I cannot tell you; the drawing would not answer
238 for a specific engine.

Q. You never saw it used with any other liquids than those you have described?

A. No.

Q. You say that water is elastic?

A. I do.

Q. To what extent?

A. To a small extent.

Q. How small?

A. I cannot tell; I cannot tell the results of Professor Henry's experiments; I have made experiments upon a large scale, in pumping water into boilers, when we found that we could get a great deal more water into the boiler
239 than it would hold if not forced; consequently, it must be elastic, or we could not have got it in.

Q. Which is elastic, the water or the boiler?

A. The water.

Q. Does that afford any test?

A. Yes; I have seen a safety-valve suddenly opened when the boiler was so filled with water, that, by its high pressure, the water would spout up through the escape-pipe into the air a distance of several feet.

Q. Is there not some recoil of the boiler to account for that?

240 A. To some extent.

Q. You know that the boiler is elastic?

A. Yes.

Q. And yet you limit the degree of its elasticity?

A. Yes.

Q. In what proportion to its bulk is water elastic?

A. Its elasticity is very small.

Q. Give us the fraction; is it one in ten thousand?

A. I do not know; it is a thing I never made special inquiry into, except the mere fact that it is elastic.

Q. As a fact in science, can you determine the degree of its elasticity?

A. No.

Q. Has it the element of elasticity for mechanical purposes? 241
A. I speak of it as slightly elastic.
Q. Is there any pressure in Sickels' water reservoir, brought upon the water, which would affect its elasticity?
A. Not sensibly.
Q. Then it is of no sort of consequence in that machine?
A. Very little.
Q. It would be inappreciable by any known mode of measurement?
A. I think it would.
Q. That dash-pot and plunger admits of being regulated, does it not, in the language of the claim?
A. To a certain extent. 242
Q. Regulating the escape of the water or fluid which is used?
A. Yes.
Q. Do you mean to say that air can be used in such a contrivance?
A. I think it could, by altering the proportions.
Q. And to regulate the descent of the plunger?
A. Yes.
Q. In the manner described here?
A. Yes; I do not see any reason why the air should not check, if the plunger is made to fit the small part of the dash-pot with nicety.
Q. Did you ever know it to be done? 243
A. No.
Q. Supposing it could be done, would it regulate the descent of the plunger by the escape of the air, or by the compression of the air?
A. By the escape.
Q. Entirely?
A. Not entirely; it must compress it a little.
Q. Would it not compress it a great deal?
A. That would depend upon the size of the opening; the vessel would have to be made larger, and the quantity of air which would be compressed, if the vessel was larger, would be smaller. 244
Q. Do you mean to have us understand you as saying that the air would not be compressed in the descent?
A. It would be slightly compressed, and that would depend upon the size of the vessel in which it fell, and the space between the side of the plunger and the side of the reservoir.
Q. Would the elasticity of air be an element which you might lay aside altogether in the descent of the plunger? Would it be as inappreciable as is that of water?
A. No.

Renwick

245 Q. Would it not be something that could be measured
and determined?
A. Yes, I suppose it could; air is more elastic than
water.
Q. In Sickels' machine, before you, is the prevention of
the slamming of the valve any object?
A. The preventing of the slamming of the valve on its
seat is a point upon which engineers differ; some say that
a slight slam is beneficial, and others say that there should
be no jar at all.
246 Q. What is your opinion?
A. As far as I am concerned, I am planning a valve with
a slight slam; I think that producing a very slight slam
would, in some cases, be good.
Q. Have you ever measured the relative velocity with
which the valves in Sickels' and Corliss' engines fall?
A. I never stood upon an engine to measure how many
inches the valve-stem moves a minute. It may be mea-
sured by a contrivance. The general opinion is that the
valve falls faster with Sickels' dash-pot than in any other
247 way.
Q. The object of that secondary reservoir is to prevent
the slam of the valve?
A. No, not entirely; because it may be used not to pre-
vent it.
Q. I speak of that contrivance as it is. Does the specifi-
cation not say that the valve shall shut without slamming?
A. I think it does.
Q. In Corliss' machine, does the valve slam at all?
A. No, the valve does not bring up against any thing.
Q. Is it possible so to arrange them that they would slam
248 at all?
A. Yes, very easily.
Q. Slam against what?
A. Against the stop.
Q. Is there any there?
A. No.
Q. Would the tripping apparatus in Sickels' model work
well unless connected with some contrivance for preventing
the slamming of the valves?
A. Yes, if it were connected with another species of valve.
249 Q. I refer to that model. I say that arrangement, as it
stands there.
A. Do you include the whole?
Q. I speak of the apparatus before you for cutting off
steam. I ask you if those valves, as they are combined and
arranged there, would be brought to their seats without en-
dangering them, unless there were some contrivance for
arresting them in their descent, and preventing their slam-
ming. I speak of the puppet-valves.

A. The puppet valves attached to Sickels' arrangement 250
for tripping, as shown on this model, would require, for the good working of them, some method of stopping them just before they got into their seats.

Q. Is it material, in Corliss' machine, to check the valves at any period before the ports are closed?

A. No, sir, it is not. You should check them at the instant that the port is fully closed.

Q. Do you consider that this sliding piece which adjusts the point of cut-off in Sickels' machine is of any value?

A. I do. 251

Q. What is it?

A. To enable men, when the engine is running, to cut off at different periods of the stroke, according to the work they wish to do; according to the pressure of steam in the boiler. There are other contingencies.

Q. The load and the pressure of the steam are changing constantly under the ordinary circumstances of use?

A. Yes.

Q. And the men must watch both?

A. Unless they put a governor on to their cut-off. 252

Q. What benefit is derived from the cut-off?

A. I explained that very fully yesterday.

Q. I will confine my question to what is gained by the using of steam expansively. Suppose you cut off at half-stroke?

A. I cannot determine the exact amount. I suppose it is a quarter of the fuel.

Q. What do you gain in the force of the steam? We will take two pounds at 50 lbs. pressure, and one at 100 lbs?

A. Take two cubic feet? 253

Q. Yes.

A. One cubic foot of steam, at 100 lbs. pressure, worked during its whole stroke, in a cylinder which holds just one cubic foot, will do a certain amount of work. Two cubic feet of steam, at 50 lbs. pressure, which can be made by the same quantity of fuel, will, in moving through a cylinder of double the size, do just the same quantity of work. Then, if you put the one cubic foot of steam, at 50 lbs. pressure, into a cylinder which holds two cubic feet, and cut off at
half-stroke, it will, when it gets to the half-stroke, have 254
done as much work as two cubic feet at 25 lbs.; and, after that, through the rest of the passage of the piston there will be a varying pressure upon the piston from 50 lbs. down to 25 lbs. All that pressure will be so much clear gain, because we have used just the same amount of fuel.

Q. The advantage in cutting off steam is the gain of the expansion?

A. That is the advantage.

Renwick

255 Q. This gain has been long known?

A. It has. It was discovered by Mr. Watt.

On being *re-examined* by Mr. Keller, the witness, Henry B. Renwick, testified as follows:

Q. Looking at this matter of the elasticity of the fluid used in the dash-pot, is not the degree of its elasticity dependent a great deal upon the velocity with which the plunger strikes the fluid, or moves through it?

A. You mean the amount to which its elasticity is exerted?

Q. Yes.

256 A. That depends upon the weight of the plunger, the distance through which it falls, and the size of the aperture, as I said before.

Q. Matters, as I understand you to say, of mere proportion?

A. Yes.

Q. In the actual working of the engine of the defendants, I understood you to say that the plunger was first brought up and then continued to move slowly for a short distance?

A. Yes. In the actual working there is no dead check of the plunger—I mean no absolute stoppage; its motion is
257 suddenly arrested, and it then continues to fall farther.

Q. I want to know whether that fact of the plunger coming down, and then continuing to move, is not evidence that it completes the last part of its motion by the escape of the air around the plunger?

A. Yes, a certain portion of it; because, if it were air-tight, it would bound back again; but I could not see any bounding back upon the engine, when at work, after the dropping of the plunger?

258 Q. In your cross-examination, you stated, that in using puppet-valves, as represented in Sickels' model, it is necessary that the plunger should check the descent of the valve a little before the valve reaches its seat; and that in the defendants' model the valve is checked just at the time the port is closed, and the valve then moves over it; and that in that state of the case the steam would slightly wire-draw in the Sickels' machine, and not in the defendants'?

A. Yes; I stated, too, that the wire-drawing could not
259 be measured.

Q. I wish to know of you, as an engineer, which would be the more economical of the two—the slight wire-drawing of the steam in Sickels' engine, or the lap of the valve consequent upon the operation of the defendants' engine?

A. That would depend upon the amount of wire-drawing and upon the amount of the lap; they might be made to balance one another, or either can be made to do a great

deal more harm than the other; it would depend upon a 260
dozen different things.

Q. Is that difference, in your judgment, material?

A. No.

Q. Did I not understand you to testify that the same lap
could be given by applying the well-known check-ring to
the puppet-valves?

A. Yes; puppet-valves with check-rings become a sort
of a compound piston and puppet-valve.

Q. Are puppet-valves always made to move upon a ver-
tical spindle? 261

A. No.

Q. Will you give any example of any different position
of the puppet-valves than that of a horizontal seat?

A. The old steamboat Novelty, as far as I can recollect,
had a puppet-valve cut-off, which was horizontal; and, in
the engine of the U. S. frigate Missouri the valve-chest
stood at an angle like *that*, so that the puppet-valves fell in
that way; and, in the oscillating engines built by the No-
velty Works, which cut off at different periods of the stroke
in their puppet-valves, the valves fall in many different
angles. 262

Q. If you should be called upon to construct an engine
with puppet-valves, upon a horizontal stem, and wished to
work upon the trip cut-off principle which is here repre-
sented, how would you force the valve to its seat?

A. I should put a weight and chain over a pulley.

Q. Could it be done by means of a rock-shaft and
arm?

A. Yes, with a weight upon the end of it.

Q. Now, in making such changes, would you require the
exercise of invention, or simply the exercise of your mecha- 263
nical knowledge as an engineer?

A. Merely mechanical knowledge.

Q. In passing from the use of one kind of valve to
another, in the construction of steam-engines, is it not ne-
cessary to change the form of the connecting parts of the
machine, to give the required movements?

A. They are very much changed in different engines;
that is, the valve-gear between the eccentric and the valve-
stem may be very much changed with the same valve, so
that a person would see the valve-gear in one and hardly 264
know it in another.

Q. Are such changes made by engineers, by the exercise
of invention or simply by the exercise of their mechanical
knowledge?

A. Some by invention and some by mechanical know-
ledge. Putting two rock shafts and connecting them to-
gether, instead of one, is what a workman would do himself.

Remark

265 There are a great many changes which are merely mechanical, and there are others which require invention.

Q. Was it in view of these changes that you have stated, that you find the defendants' machine and that of the plaintiffs to be substantially alike?

A. I find substantially the same devices for hooking and unhooking the valve; but I do not mean to say that I ever saw them arranged precisely as they appear in Corliss' model before.

Q. Is there anything stated in Sickels' specification as to
266 the manner in which motion is to be communicated to that stem or lifting rod?

(Witness referred to the specification and read the manner in which motion is described as being communicated to that stem.)

Q. I will ask you whether the lifting rod is not sometimes, in engines, operated by means of a jointed connecting rod, extending to a rock-shaft?

A. It was one of the earliest ways of moving it.

Q. And in the engines having sliding valves, do they use
267 these secondary rock-shafts with the toes?

A. They use no toes in engines with sliding valves generally.

Q. What is *this* rod?

A. That rod would become, in the ordinary form of sliding valve engines, a prolongation of the valve-stem; it would change its name according to its purpose.

Q. That is the most general form of common sliding valves?

A. Yes.

268 Q. I will ask you whether there is not known in mechanics a great variety of modes for latching and unlatching, by means of wedges, inclined planes, cams, and a great variety of other instances?

A. Yes, any number of them.

Q. Is that form of latching and unlatching the lifting rod from the lifter or arm on the stem of the valve, in the defendants' model, a formal or a substantial change from the form found in Sickels' patent?

269 (This question was objected to by the defendants' counsel, as re-opening the direct examination, and was ruled out by the court.)

Q. In view of the differences which you have specified as existing between the defendants' and plaintiffs' models, in the mode of unlatching or disconnecting the lifting-rod from the lifter, is that difference substantial or formal?

A. I said that the difference was formal; they are substantially the same methods of tripping the valve from the mechanism which moves it.

Barnum

The plaintiffs' counsel then called as a witness: 270

Daniel Barnum, who, having been sworn, was examined by Mr. Keller, and testified as follows:

Q. Where do you reside?

A. I reside in the city of New York.

Q. Will you state to the jury what have been your means of acquiring a knowledge of mechanical science applied to the arts and of the progress of inventions?

A. I have been engaged in mechanical pursuits from the age at which I was old enough to be employed at 271
any business, and that is sufficient to indicate that it is 30 odd years; for the last 25 years I have been engaged more or less in running machinery, and in operating it in various ways.

Q. Have you particularly turned your attention to the principle, construction and working of steam engines?

A. Well, I have had something to do with them—considerable.

Q. Have you read Sickels' patent for cutting off?

A. I have read a copy of it.

Q. Are you practically acquainted with its working?

A. I have seen it in operation in various instances— 272
generally on board of the boats which have been used about New York and other places.

Q. Have you examined the model of the defendants' engine?

A. I have looked at it.

Q. I will get you to state to the jury what, in your opinion, is the combination of machinery by which the valve is tripped and closed, as described in Sickels' patent?

A. The combination of machinery consists in a lifting rod, a lifter, and the valve stem for raising the valve, and 273
springs, which is operated by a wedge, shown upon the model, for tripping it and allowing it to fall; it is arrested by a dash-pot, which is shown here below; that is to be filled with a fluid, which is to arrest it just previous to the point of concussion of the valve and its seat.

Q. I will get you to examine the defendants' model, with reference to those two things—the combination for tripping, and the mode of arresting the valve. State whether they 275
are substantially alike or substantially different, and explain your views to the jury as clearly as you can.

A. I may not be able to do it as scientifically as Mr. Renwick, for I do not pretend to the scientific attainments of that gentleman. The point, however, as I understand, to be gained, is to have the valve, through a combination of machinery attached to the moving mechanism, so that at the proper point, when the piston is ready, upon one end of

Barnum

276 its stroke, to receive steam, to have the valve raised and to carry that valve, by the motion of the mechanism, to a point that is desirable to cut off, when, by a mechanism, it is detached, and the valve falls to its seat, the moving machinery continuing to perform its entire revolution, so that the steam may act expansively from the time of cut off, to finish its entire stroke.

Q. The valve being left in a condition to be re-engaged with its machinery?

A. Yes; it is carried back to its original position.

277 Q. So far as regards the combination for effecting that purpose, do you find it in the defendants' model substantially different from that found in the plaintiffs'?

A. To my apprehension, it is substantially the same; the same ends are obtained, and by, what I should conceive to be, substantially the same means.

Q. In the defendants' model, is there any necessity for the employment of a means to check the valve at the time of its closing?

A. In the defendants'?

Q. Yes.

278 A. Well, I should apprehend that there was.

Q. How is that done in the defendants' model?

A. It is done by a dash-pot which is filled with fluid, through which the plunger moves until it comes to the point, or nearly so, of closing the valve, when it is arrested by that fluid escaping from the cylinder, upon which the plunger rests, and arrests its momentum and covers the seat.

Q. In that particular, is the defendants' model substantially alike or different from Sickels'?

279 A. I think they are substantially the same. A different fluid is used, but not constituting, as I apprehend, a difference in the principle of the arrangement or operation.

Q. Turn your attention now to the plaintiffs' dash-pot, as it is termed. As the plunger descends into the cup, does the plunger gradually contract the aperture through which the fluid passes?

A. Of course it does.

Q. Is it by that means the descent is checked?

A. It is by that means that it is practically and positively arrested. By that means it is done in such a way as to produce no sensible concussion.

280

Q. By gradually reducing the size of the aperture?

A. Yes.

Q. Here is the defendants' plunger. (Handing it.) As that plunger descends, does it or not gradually contract the aperture through which the fluid escapes?

A. This cylinder appears to have a bore of equal diameter

during its whole length, and there appears an orifice open- 281
ing nearly at the bottom of it, which permits the free escape
of air, until the plunger comes to the upper edge of that
orifice, when, as a matter of course, passing over, it dimin
ishes that orifice until it has entirely passed it. Then it is
effectually closed, and there is no escape except what can
be had around the periphery. After it has passed the
orifice, then it is arrested. The air is prevented from
escaping, and the weight of the metal that rests upon the
fluid there confined below that orifice is so very small, that
it must be arrested almost instantaneously. It cannot pro- 282
ceed very far, because the air that is confined there would
prevent those surfaces coming together, provided they were
mechanically true, so that the distance it could travel after
that must be very slight.

Q. In the operation of rotating or sliding valves, in what position should the valve be, to work with most efficiency at the time of cutting off the steam, with reference to the port?

A. At the time that you cut off steam, as a matter of
course, the position of the valve should be to cover the 283
entire opening.

Q. Is it material that the valve should lap considerably, or just close the aperture?

A. When the port is closed, so far as the operation of the steam is concerned, the whole thing is done, and if it moves any further it is mere waste of power.

Q. Are you acquainted with the check-ring, as used in puppet-valves?

A. I think I know what it is.

Q. Where the check ring is used, in connection with the 284
puppet-valve, does it require the same nicety of adjust-
ment of the plunger to its cup that is required when the
check-ring is not used?

A. It cannot require the same adjustment, because there is a space. The check-ring is not supposed to be so tightly fitted as to cause a complete stop. It would allow of more play in closing it, and it would form a part of the means of arresting the valve.

Q. Is that equivalent to the lap of the slide or rotating
valve? 285

A. Yes, sir, I should think it was.

Q. Admitting the same range of motion?

A. Yes.

Q. Now, sir, in your judgment, would the arrangement described in Sickels' patent be changed in its operation, as a mode of closing the valve, by substituting any other fluid for water?

A. I should think not, sir. It might require a different

Barnum

286 adjustment, or a different proportion of the parts, but the same end, and in substantially the same way, could be arrived at.

Q. Now, sir, in this model of the defendants', suppose that portions of this outer cylinder were cut away down to the level of that hole, leaving only some ribs as guides for the plunger, would it act differently from what it does in its present form?

A. So far as that is concerned substantially, I think it would make little difference. The arrest takes place at the point where you close the opening.

287 Q. If we should place the defendants' dash-pot in a vessel of water, and this hole in the side were made sufficiently large in proportion to the density of the fluid, would it not work in water as it does in air?

A. Substantially the same. The only difference would be in the density of the fluid. You would want a larger opening to let the fluid escape.

On being *cross-examined* by *Mr. Jenckes*, the witness Daniel Barnum testified as follows:

288 Q. Have you ever been a builder of steam-engines?

A. I have been interested in their building?

Q. Have you ever been practically engaged?

A. I have, sir.

Q. In what capacity?

A. In the capacity of owner and operative.

Q. As draughtsman?

A. No, sir.

Q. How many did you ever build?

A. That is more than I can tell now. I never have built
289 or constructed more than one to apply to a boat.

Q. How long since you have been engaged in it?

A. For the last year.

Q. How many stationary engines have you ever built?

A. I have been interested where there have bee nIc annot tell how many.

Q. Interested for the last year?

A. Within the last nine months of the year I have not been interested in any. Previous to that I was interested in stationary engines, that were building at the foot of
290 Twenty-ninth street, in Mr. Wells' machine shop. I have built a good many, but I cannot tell the number.

Q. How long a period have you been engaged in building?

A. I was interested with him about two years.

Q. You spoke of a check-ring applied to puppet-valves—how long have you been acquainted with that contrivance?

A. I have known them for a number of years, but I cannot tell how long. 291

Q. Twelve years?

A. No, sir, perhaps not twelve years—I do not know but it is.

Q. Do you know who it was invented it?

A. No, sir; I know who used them, or I have heard the names of those who used them.

Q. Do you or not know that it was invented within twelve years?

A. No, sir, I do not know that it was.

Q. You do not think that you saw it until within that time? 292

A. It may be within that—I cannot undertake to fix the time with regard to that.

Q. You say that this brass model—the defendants' reservoir and plunger—would work as well with water as air, by increasing the size of the orifice?

A. I said if this, or one like this, had sufficient opening to permit water to escape, that I thought it would work equally well.

Q. Would it be necessary to make any additions to the model, in order to complete it for that purpose, or would it work just as well as it is? 293

A. I do not know as it would.

Q. What is necessary to add to it?

A. I do not know that anything would be necessary.

Q. Is that complete now for use as a water dash-pot?

A. No, sir.

Q. How would you complete it?

A. There is nothing to adjust the water to its parts.

Q. There is no water there, either? 294

A. No.

Q. How would you provide for the water?

A. I suppose, as a matter of course, it would be immersed in water.

Q. Then there must be water surrounding it?

A. Yes.

Q. Is it complete as it stands for that purpose?

A. No, sir.

Q. You would put an outside case around it, and enlarge the aperture? 295

A. Yes, this would regulate the cup.

Q. Do you mean to say that by enlarging the aperture, and putting an outside case around it, it would be substantially like Sickels'?

A. I think it would operate like Sickels'.

Q. Would it be substantially like?

A. Substantially I think it would, and arrest the valve at the proper time.

Barnum X

296 Q. Confine the answer to the question. Would or not a device of the kind you have described—water enclosing this model, filled with water, and the aperture enlarged—would a contrivance of that sort be substantially like Sickels', in its arrangement and purpose?

A. I think it would, with the adjustment I have spoken of.

Q. How would you have the adjustment?

A. I would adjust it to the point at which you wanted to raise the valve or lower it.

297 Q. Have you ever seen a dash-pot of the kind that you now describe, without the adjustment described, anywhere except in Sickels' patent?

A. I do not know that I have.

Q. A straight dash-pot?

A. I do not remember that I have.

Q. Are you acquainted with works upon the steam engine?

A. I do not profess to understand the science as well as the witness who preceded me.

Q. There would be two great elements in such a dash-
298 pot—a straight cylinder, with a plunger working in it, and an aperture through which the water is to be thrown into the cylinder, and out of which it is to be forced?

A. Sufficient to give entire freedom.

Q. A dash-pot or reservoir, generally filled with water, containing a straight cylinder like this, with a plunger working, and an aperture through which the water is admitted into the cylinder, and out of which it is discharged back into the reservoir surrounding it, would be a dash-pot for checking the valve, substantially like Sickels'?

299 A. I would say, if the orifice was sufficient to give a free passage, so as not to be obstructed sufficiently to prevent the descent of the piston, that it would be substantially the same.

Q. Take the wooden model of Sickels' dash-pot, which is beside you. Does that represent the dash-pot as delineated in the drawing attached to Sickels' specification?

A. Not in all its parts.

Q. What parts are omitted?

A. In Sickels'?

300 Q. Yes.

A. I believe it does. I believe that is substantially represented as you have described.

Q. Could you use air with that, to effect the purpose which Sickels claims to effect?

A. I think that would depend upon its proportions. I think that air might be used with one constructed upon that principle.

Q. Have you ever seen it used in Sickels'.

A. I have never seen it used, but I have heard that it has been used.

Q. Have you examined the specification and drawings of 301
Sickels' patent?

A. I have read the specification over, but not with very great care.

Q. Is the dash-pot constructed according to the description, and according to the drawing?

A. He speaks there of a reservoir and secondary cup, and of the opening through the plunger for water to escape, which substantially corresponds.

Q. If you were to use air in that reservoir, would you use
a secondary cup? 302

A. A secondary cup is employed for the purpose of adjustment, and if you were to use air you would want something to answer that purpose; for an adjustment must be made to use air.

Q. Could you use it in that form?

A. Not in that precise form.

Q. Do you know of any form in which you could use it successfully for that purpose, with a certainty of producing that result?

A. I think so. I think all you would require would be 303
to have your area sufficient, and the escape of the air sufficiently near the bottom.

Q. What do you mean by the word escape?

A. The escape of air.

Q. Do you mean escape through the side of the cylinder?

A. When the plunger strikes the cylinder, whatever air would be beneath it would be confined there, so as to arrest, by its confinement, the motion of the plunger.

Q. You speak of the escape of air. Do you mean through
an orifice? 304

A. Either through an orifice or around it. It is immaterial.

Q. You have never tried it?

A. I have not.

Q. Nor seen it tried?

A. No, sir.

Q. You do not know whether it would work or not?

A. I have no doubts upon that subject.

Q. You think you could construct a reservoir to use air,
upon the plan indicated in that model? 305

A. Substantially.

Q. You say that you have not examined this specification?

A. I have read it, but not in a critical manner.

Q. Have you compared the drawings and specification with the Sickels model before you?

A. I have looked at them with reference to that.

Q. Can you construct that model from the description and drawing?

306 A. I think I could.

Q. And with your skill as a mechanic, could you construct Corliss' machine from the description attached to this patent?

A. If I were to take the parts separately, I could not put it in that form precisely, but I think there would be no difficulty in arranging so as to attach and detach the valve substantially in that way.

Q. Following the language of this description?

A. If I were to follow the language of that description
307 literally, I would say "no."

Q. Do you find any general language there that indicates another mode of construction?

A. There is always a general idea in reading a description, to adapt the principles of machinery to the particular uses desired, and you cannot expect to follow literally the construction.

Q. Do you find any thing in this specification which would show you how to work with slide or circular valves?

308 A. You find there a complete description for operating valves, so as to detatch them and cut off steam by the main valve; and by applying those principles to different forms, or to different positions, it would require, as a matter of course, that different forms should be adopted, retaining, substantially, the principles and ideas which are associated with that arrangement.

Q. Have you ever seen a machine of Mr. Corliss' in operation?

A. I have, sir.

309 Q. Where?

A. I have seen one within a few days, which was pointed out to me as his engine. I have seen one running in Centre street.

Q. The one at the Crystal palace, do you mean?

A. Yes; although I never went into an examination of it, with a view to understand its details. I have observed its mode of dropping the plunger, so as to see the resemblance it had in this respect to the dropping of Sickels' valve. I did not know at the time whether slide or puppet-valves
310 were in use there.

The court then adjourned to December 26th, 1854, at 11 o'clock, A. M.

December 26th, 1854, 11 o'clock A. M.

The plaintiffs then called as a witness, James J. Mapes, who, having been sworn, was examined by Mr. Keller, and testified as follows:

Q. Will you state to the jury what have been your means of acquiring a knowledge of steam engines, and gene-

Mapes

rally of the progress of the arts, and what constitutes the 311
difference between an invention and a mere formal variation?

A. I have been engaged for twenty years, or more, as consulting engineer, and have been often consulted as to the value of inventions, by inventors and purchasers, and have been frequently called as an expert in patent suits.

Q. Have you examined the patent granted to F. E. Sickels, on the 20th of May, 1842, for improvements in the method of operating steam cut-off valves?

A. I have. 312

Q. State whether that (handing model of Sickels' patent) is a correct representation of the invention described in that patent?

A. I think so.

Q. I will get you to state what, in your opinion, is the combination of mechanism which you there find, for the purpose of lifting and tripping the valves, in order to cut off steam?

A. I find a lifter, armed with two springs, capable of en-
tering notches upon the valve-stem, and thus ensuring its 313
being lifted. I find also an adjustable stop, carrying an inclined plane, which forces apart the springs which form the attachment between the lifter and the valve-stem, so as to break such connection at any desired point.

Q. What is the purpose of breaking that connection at any desired point?

A. The purpose is to disconnect the valve from the other parts of the engine—the lifting portions of the engine—and to do it at any point required. The object of this connec-
tion is to permit the valve to close the port, and thus cut off 314
the steam at any required portion of the stroke, so that it may be used expansively, and thus more economically.

Q. Could not the valve be closed again by the mechanism itself, without separating it from the mechanism?

A. It could; but it would be closed slowly and cause the steam, therefore, to be wire-drawn, not leaving an opening sufficiently large to leave the piston under the same pressure during the filling of the cylinder as the average pres-
sure in the boiler. 315

Q. Why will this effect it and not the other?

A. Because it permits the valve to fall by its own gravity, and even assists the rapidity of its descent, thus causing a sudden shutting of the port.

Q. What, in your opinion, is the mode of operation of the apparatus found in the patent for regulating the closing of the valve?

A. The valve, being of great weight, and falling through some distance, unless checked at the immediate point of

316 contact with its seat, would abrade itself and the seat, so as
to become disordered. To remedy this defect, called the
slamming of the valve, the valve-stem passes down through
the steam chest and enters the cylinder below; the termi-
nus of this stem being armed with a piston, or an enlarge-
ment of itself, which, in the lowest part of its descent, is
received in a cup, approximating towards its own figure.
This cup and the cylinder above it contain water, through
which the descending piston passes freely, until it reaches
the opening of the cup, when it is suddenly checked, and
317 thus receives the momentum of the falling valve, diffusing
it by the constant action of the water, instead of its being
exercised with a hammer-like action on the valve-face, and,
of course, preventing abrasion of the surface.

Q. In technical language, what does the term "fluid"
signify?

A. Well, sir, in strictly technical language, it signifies all
those substances which are usually designated liquid and
äeriform.

318 Q. Is water a non-elastic body?

A. Strictly no. Water, practically, is elastic from the
elasticity of the amount of atmospheric air it contains; also
from the elasticity of the amount of carbonic acid gas it
contains under all ordinary circumstances; and this amount
is large whenever it is churned, as in this cylinder. But
water is also elastic, pertinently, from the mobility of its
mass, its propensity to find its level, and the ease with
which portions of it can be thrown through narrow spaces,
319 like the annular space existing between the inner diameter
of this pot and the piston which enters it. The ease with
which it may be thrown up into the cylinder, and the im-
mediate ability it has to find its level, constitutes it, mecha-
nically, to a certain extent, spring-like. But water, en-
tirely freed from atmospheric air and carbonic acid gas, in
its pure state, has been proved by Ericsson's hydrosympie-
someter, not only to be elastic, but to exhibit the ratio of
elasticity and to register its elasticity.

Q. As a question of science, is not the resistance of any
fluid, whether äeriform or liquid, dependent upon the velo-
city of the body which passes through it?

320 A. Of course; I suppose that, theoretically, a hammer
may be thrown upon the surface of water so much more
rapidly than the ultimate particles of the water can change
place, or be put in motion, that the hammer and not
the water would be abraded. On the same principle, we see
a tallow candle fired through an inch plank, when thrown
from a gun; although the candle may be nine hundred
times as soft as the plank, if it moves with a thousand times
the velocity, it will act as a cutting instrument, and make a

hole through the plank. For the same reason it is that a 321
wheel of paper, with rapid action, would cut a bar of steel.

Q. Is there any practical example in the arts, in which a soft substance, moving at a high velocity, would abrade, not itself, but the hard substance with which it is brought in contact?

A. Yes, many; a wheel of soft sheet iron is used to cut steel screws; it is the intrument really in use and practice for that purpose.

Q. As a question of science, when a fluid is to be used as
a resisting medium, is it a matter of election, depending 322
upon the velocities, or is it absolutely necessary that any one single fluid should be selected as a means of resistance?

A. It depends upon the use; I suppose, in view of the known facts relative to the use of fluids for analogous purposes to that here described, that it called for the exercise of skill, and not of invention, in either the selection or adaptation of both the fluid and the parts by which it was rendered active or useful.

Q. If you were asked to apply Sickels' invention, as you
find it in the patent, and substitute air for water, what 323
changes would be necessary to be made in your judgment?

A. I should suppose that it would be necessary to prevent the escape of air at a point collateral with the exact point of the closing of the valve, so that the piston impinging upon the air should not, at that time, be gradually but suddenly acted upon.

Q. Well, sir, would such a change, in view of the description in the patent, call for the exercise of invention?

A. I think not, when taken in connection with the whole
subject as it stands before us. 324

Q. Have you examined this model of the defendants' engine?

A. I have.

Q. I will ask you, sir, in reference to the combination of machinery for tripping and closing the valves, if it be substantially like or substantially different from the combination found in Sickels' patent?

A. I am clearly of opinion that they are substantially alike, and that, in view of this machine, which is described
in the patent as evidently one of the many forms of valves 325
then known and in common use, but selected simply as one, that description, as there given, would enable any mechanic, well versed in the history of the art, to adapt the invention of Sickels to either of the kind of valves in general use, and that by the exercise of mechanical skill alone, and not calling for invention.

Q. Now, sir, in reference to the mode of regulating the closing of the valves, is the apparatus represented in the

Mapes

326 defendants' model substantially like or substantially different from that described in the Sickels patent?

A. It is substantially like, and particularly when applied to the substantial purpose for which it is used. In Sickels' arrangement, the blow, or slam, is upon the valve itself. In Corliss', or any other where a rotating or slide valve is used, a weight or spring must necessarily be applied to insure the closing of the valve; the weight or spring then, or body put in motion at an accelerated rate, regulates, for all practical purposes, the descending piston in the dash-pot of
327 Sickels, and the jar consequent upon the falling of this weight, intended to close the valve, must be diffused, as a jar upon such a weight would injure the machiney and abrade its parts, as much as would the slam direct upon the puppet-valve, and therefore it suggested itself to the mind of the constructor, that a dash-pot, or its equivalent, must be applied to some portion of this falling mass, so as to arrest it at the precise point, or near it, that would close the valve, which differences, in that case, are formal and not
328 substantial.

Q. Now, sir, in this model, (Corliss'), when the valve closes, the edge of it moves some distance beyond the aperture of the steam port; is there any advantage in having that edge of the valve to move beyond the port or beyond the point necessary actually to close the valve?

A. No; that which will practically close it performs the full office of that valve.

Q. As it moves beyond the edge of the port, I want to
329 know whether that amount of motion which is beyond what is necessary to close the port, and then back again to reopen it—I want to know whether that induces a loss of power in the engine?

A. Yes; and not only in the engine, but permitting the weight to fall through a greater distance, there is greater difficulty in arresting it.

The Court.—Where do you mark the slam or jar which is prevented by a dash-pot?

A. Whatever weight is attached to that valve (illustrating on Corliss' model) to cause it to rotate, you have only
330 to trace to the point where that weight is, and there is the place where you wish to arrest the momentum.

Mr. Keller—

Q. If that weight which is thus hung to the stem, for the purpose of rapidly closing that valve, were permitted to come in contact with the solid body of the machine, to arrest it, what would be the effect upon the machine itself?

A. It would abrade the valve, destroy it and all other parts of the machine in a much shorter space of time than

by ordinary wear and tear. We all recollect before the introduction of this invention, the shaking on steamboats. 331

Q. If I take a body of metal, or a series of pieces of metal, connected together, and permit the whole mass to fall and come in contact with a solid body, does that blow affect merely the parts coming in contact, or does it affect the entire mass?

A. It affects all the parts through which that jar or slam can be communicated.

Q. Do you know of any example in machinery in which that has been manifested? 332

A. Yes; every trip-hammer would manifest it fully, and every pile-driver, and every wagon.

Q. I will get you to point out upon Corliss' model, and to give your reasons to the jury, why you find the combinations in this machine to be substantially the same as that described in Sickels' patent, for elevating and tripping the valve, or rather for opening and closing the valve?

A. I find the valve-lifter (which, in Corliss' machine, is a bending of the prolongation of the valve-stem) here, as also the part to which the weight is attached. I find that to be 333
operated upon by parts here that are entirely analogous to parts represented in the Sickels machine. Thus I find the inclined plane (which, in Sickels', is upon a stop) is, in Corliss', divided among the parts, instead of being resident at any one point. You will perceive, during the rotation of Corliss' machine, if you will follow that line, as compared with the next position it will assume, that the line here represented, as compared with the other, is a wedge, and that it is maintained below the bottom of this stop (illus- 334
trating). By the location of this stop you may perceive that *this* is taken away from its connection *there*, precisely for the same reason that the springs are taken away in Sickels', namely, by the inclined plane breaking the connection between the valve and the lifter. It is by a different arrangement of the parts, such as any mechanic would be compelled to adopt, (this or some other,) when he finds the action required must be moved in its pertinent points of application. He adopts substantially the same parts, but under the form of a different arrangement, leaving them 335
substantially alike, and only different in form.

Q. Are such variations of known mechanical arrangements in form rare or frequent in machine shops?

A. They are frequent; as frequent almost as the necessity for altering the figure of a cam, which is intended to alter the direction of motion.

Q. Now, sir, if you had a shaft placed here with a tappet upon it, geared in connection with the engine, so as to come around and strike *this* off at the time required, would the sub-

Mapes

336 stitution of such a rotating cam for the inclined planes described in Sickels' patent, be a substantial change or merely a formal change?

A. Merely formal.

Q. Taking this (handing model of defendants' dash-pot), will you explain to the jury, upon that model, why it is that you deem that mode of arresting the valve used by the defendants as substantially like the mode described in Sickels' patent, as an apparatus?

337 A. First, because it was well known that air, in a confined
space, played the part of a solid body, or approached that
condition precisely in the ratio of the speed of motion of
the substance impinged upon it. It would be evident to
any mechanic, in the operation of this dash-pot, that if the
speed of motion of the descending piston was not partially
regulated while falling through the water in the upper cy-
linder, that, on meeting the cup barely filled to its surface,
338 he would not rid himself entirely and perfectly of the slam
by that water's gradually changed figure, beyond a mere
immersion of the part in the more quiescent portions, (I
mean changed figure in the surface of the cup). Corliss'
contrivance embraces the same thought in a different form.
There is a hole here at the side which permits the escape
of air, as this piston falls, but the hole is not so large as
the diameter of the cylinder, and hence it partially affects
the falling body, but not so that the difference in the space
is observable, until it arrives at the upper edge of this hole;
339 and this hole, as compared with the whole size of this mass,
is in the same proportion that the more elastic fluid, air, can
be got rid of, as compared with water. When this piston
arrives at the upper edge of the hole, it commences to close
it, and hence gradually lessens the amount of escape, and
therefore gradually to impinge upon the solid air, after the
hole is entirely closed, and there is no escape. The term
"gradually" there, you will readily perceive, applies to a
very short space of time, although during that very short
space of time all those conditions do occur. This, then, is
so configured as to play all the pertinent parts of this dash-
340 pot, and particularly to adapt it for a separate locality, as
is called for in their arrangement.

Q. I think I understood you to say, that in Sickels' patent, as the dasher or plunger descends and goes into the cup at the bottom, it contracts the aperture through which the water escapes from under the plunger. What is the form of that aperture?

A. It is an annular space; the falling piston and the cup are concentric with each other, leaving an annular sheet of water to be forced into the mass of water above.

Q. Is that aperture reduced in size, as the plunger descends, in Sickels' engine. 341

A. Yes.

Q. Then I understand you that in both these dash-pots' the plunger, as it descends, gradually contracts the aperture through which the fluid escapes?

A. Yes.

Q. And for that reason you deem them to be analogous?

A. Not for that reason alone; but they are analogous from the offices they perform.

On being *cross-examined* by Mr. Jenckes, the witness, JAMES J. MAPES, testified as follows: 342

Q. In the machine of Corliss', when is the plunger in the dash-pot first arrested—at what part of the motion of the valve?

A. Well, sir, I shall have to trace it out upon the machine and find where it is first arrested. It commences to be arrested whenever it abridges the delivery of the air under the dasher, and it commences that abridgment as soon as it commences to cover the hole through which it escapes. 343

Q. Is the port open or closed when the weight reaches the hole through which the air escapes?

A. It may be either.

Q. Will you examine in the model and see?

A. Well, sir, I do not think that in a model like this you can exactly tell. The model is made so imperfect, that they do not act alike. I do not consider it material, however, to either the action of the engine or the apparatus; for, being a rotating valve, even if it passed the port, it does 344
not affect it.

Q. How is the fact in Corliss' model? Is the valve closed or not, at the time when the weight reaches the aperture?

A. I suppose it is about closed at about the time that the weight reaches its final seat. I cannot judge from this model.

Q. Have you ever seen an engine of this kind in operation?

A. No, I have not. 345

Q. And you do not know the practical working of this dash-pot?

A. Except so far as I can deduce it from what has been here exhibited, and the patent.

Q. Do you think it is material whether the weight in Corliss' model is checked before the port is closed, or after it is closed?

A. Yes, I do.

Q. How so?

Mapes F

346 A. I think that weight ought to be checked at such time
as the valve has performed its office; because the valve can
have no motion after that check.

Q. Do you mean to say that it ought not to be checked
until the port is closed?

A. I have not so said; I do not practically know, unless
so far as I can deduce it there. My opinion is, that the ac-
tion of that dash-pot should occur as the action of the dash-
pot in Sickels'—at the instant of the closing of the port, for
347 the most economical action. If it occurs after, it is because
the valve has passed an unnecessary distance.

Q. In Sickels' model, does not the checking always take
place before the valve is entirely closed?

A. Well, sir, practically an instant before; but it is so
small a space of time, that you speak of it for practical pur-
poses as simultaneous action.

Q. Is it possible for a check to take place after the valve
is closed, in Sickels' machine?

A. No, sir.

348 Q. It is possible in the model of Corliss'?

A. Yes; it would be possible to take place anywhere;
but it does not become pertinent to its office, when taking
place at any other time.

Q. In Corliss' model, is there any necessity for checking
the speed of the piston before the valve is closed?

A. You cannot check it as soon as the port is covered,
unless you commence that operation before it is entirely
closed.

349 Q. Do you mean to say it is not possible unless you
check it before?

A. I think it is not possible; I think there is no such
thing as "a line in time," to be so applied, without approxi-
mating your contrivance here to covering that side hole.

Q. Is there any perceptible checking of the motion of
that piston, until the plunger reaches the aperture?

A. I think not, in this small model; but that there is such
a gradual effect cannot be doubted. Whether it can be per-
ceived is another question. I suppose it can in a very large
350 one, but not in these models.

Q. When the valve is entirely closed before the piston
reaches the orifice, there is no wire-drawing of steam, is
there, through the port, during the operation of closing?

A. I should think, sir, that there might be; it would de-
pend upon the speed with which it is closed. There would
be none, I consider, with a falling weight.

Q. If closed by the speed of a falling weight, there would
be none?

A. No.

Q. In Sickels' model, must there not be a partial wire-

drawing of the steam at that point, or the point of closing? 351

A. I think not.

Q. Practically?

A. Practically, I think it works as closely as any other contrivance.

Q. Have you seen an engine of that kind in operation?

A. I presume I have seen many of each, but I cannot name now the exact engines, &c. I think I have seen each, but I do not recollect upon what boats or at what factories. I have, however, seen similar modifications.

Q. Can you recall to mind any engine of either kind that 352
you have seen at any particular place?

A. No, I do not know that I can by name—not looking at them with a view to any such distinctions, and seeing engines almost every day.

Q. In Corliss' model, would the valves slam, if there were no contrivance to arrest the descent of that weight?

A. Yes, sir, they would, in common with all other parts that were sufficiently free to represent surfaces moving on each other.

Q. Do you understand, by the slamming of the valves, in 353
Sickels' model, the meeting of the face of the valve with its seat?

A. I do.

Q. Is there any violent meeting of the face of the valve with its seat in Corliss' model?

A. It is in a degree there; you would have it in part; that valve would not rest there without a dash-pot or its equivalent.

The Court: Q. If not counteracted, what would the valve strike against?

A. Your Honor will perceive that a jar, like the blow of 354
a hammer, would occur; the jar would first occur upon the falling weight, and be thence communicated to this rod which is attached to the valve, and would be felt upon all parts of the engine, just as the blow upon the end of an axe-handle with a hammer is felt upon the axe which is loose upon its end, and causes it to find its solid place.

Mr. Jenckes: Q. There is nothing particular for this valve to come up against?

A. Yes, that space; consequently any momentum of the 355
machine will affect it; every bearing connected with that stem (illustrating on model,) and that stem, must receive, although not in the same figure of a slam, still a slam.

Q. Is the face of this valve, (Corliss') ever lifted from its seat?

Mapes

356 A. It is turned from its seat.

Q. Is it not turned *on* its seat or face?

A. No, sir, it is not.

Q. Is it not always in contact with the face, or some portion of the face?

A. With some portion of *a* face—yes; it is *its* face only so far as it is in the habit of acting.

Q. By any shock in this machinery, is this valve ever brought in more violent contact with its face than it is
357 while it is in motion or while it is at rest?

A. Yes, sir; the jar upon one part of a board that is pressed upon by a spring upon another part, will cause a greater action of that spring.

Q. Would it cause the face of this valve to press against its seat with greater force, in any portion of the model?

A. Yes; not as a continued force, but as an absolute momentum from that blow, if not checked.

Q. Does not Corliss' valve revolve upon its shaft?

A. It does.

358 Q. Is not the motion of this shaft that of an ordinary rock-shaft?

A. Yes.

Q. Can the face of this valve be brought with violence against its seat, except by bending that shaft?

A. It depends upon the strength of that shaft and the weight of the valve.

Q. Suppose it is in the proportion represented in the model, would the action of that weight, which is here sufficient to close it, bring the face of this valve against this
359 valve-seat, in any portion of its operation?

A. It depends upon the accuracy of that valve to its seat; it depends upon the bearing on the top of that valve-chest.

Q. Suppose you strike it a blow with a hammer, does that bring the valve-face and its seat in more violent contact, or does it slide the valve upon its face?

A. You cannot make a shaft practically so large that by absolute momentum its figure will not be altered; and, in so doing, if that valve has any length, it will abrade the
360 face.

Q. Will it be altered anything more than an imaginary distance out of its line of motion.

A. Sufficiently potential to be of value where high steam is used.

Q. Is the line of its motion ever upwards and downwards?

A. No.

Q. In order to bring the face of the valve against its seat, it must have a motion upwards and downwards?

A. No, sir, a rock would do it, and a momentum will rock that valve-stem, if it be sufficiently severe. 361

Q. Will it, unless it be sufficiently severe to bend that shaft?

A. A bending and a momentum are different; you may do it upon a shaft of six inches diameter with a one-pound hammer in your hand.

Q. You have not examined the machine, and you do not know whether there is sufficient to bend that rock-shaft?

A. Take away the dash-pot, and I suppose there will be; 362
but I think there must be such as would derange in time that valve in its action.

Q. Not from any impingement?

A. Not as there applied.

Q. The jar which is here checked is at the extremity of this rod, is it not?

A. It is when it occurs, and thence is diffused through all connecting parts.

Q. The jar upon Sickels' model is upon the face of the valve and its seat? 363

A. Yes, and every other place connected with it.

Q. Primarily upon its face and seat?

A. Yes.

Q. That is where the shock is received?

A. In the absence of the dash-pot, yes.

Q. Does not that compression tend to injure the face of the valve, and to cause it to leak more or less?

A. Undoubtedly, in the absence of the dash-pot it would not be a practical valve; the immediate effect of that concussion is to injure the face. 364

Q. The jar to the valve and the other portions of the machinery—is that of any consequence compared with the injury to the face of the valve?

A. It is of consequence to the extent that it deranges it.

Q. Comparatively, in the use?

A. Comparatively, I think it is of consequence; it would render the valve inert in a single day, and would wear out the machinery in half the usual time.

Q. Which is of the greater consequence?

A. The valve itself, because the engine cannot work 365
without it.

Q. In Sickels' arrangement, how is the valve thrown from its seat? How is it opened?

A. By the action of the lifter.

Q. By what mechanism connected with it; how do you understand it to be raised in the description of the patent?

A. I do not recollect if he says at all, in his specification, how it is to be lifted.

Mapes

366 Q. In the usual way—"The valve stem is to be raised by the lifter E, which is acted upon in the usual way."

A. This is raised perpendicularly by any of the contrivances that are used for that purpose.

The court then adjourned to December 27th, 1854, at 11 o'clock, A. M.

December 27th, 1854, 11 o'clock, A. M.

The witness, James J. Mapes, on being further *cross-examined* by *Samuel Blatchford, Esq.*, one of the counsel for the defendants, testified as follows:

367 Q. In the defendants' engine, where do you perceive any regulation of the closing of the valve by the apparatus?

A. I perceive that to be regulated by the point at which it is permitted to trip.

Q. I mean the regulation of closing in connection with what you call the dash-pot—regulation by the weight?

A. I understand that when the valve is tripped, the weight then tends to throw it back to its original position—to its statical position.

368 Q. That is what you mean by regulating the closing?

A. That is what I mean by the closing; as to regulating the closing, so far as preventing a slam, the remedy is to be found in the dash-pot.

Q. Independent of preventing a slam, where do you find any regulation of the closing in connection with the falling of the weight?

A. I find it in the falling of the weight, and nothing but the falling of the weight.

Q. Do you mean the falling of the weight without refer-
369 ence to the checking of it?

A. I mean the falling of the weight tends to close the valve; the prevention of the slam is from the operation of the dash-pot upon that weight.

Q. Then the regulation of the closing, and the closing, you understand to be one and the same thing?

A. I understand that they are here combined and are a continuous operation.

Q. What do you mean by the regulation of the closing, in the Sickels' arrangement, in connection with the descrip-
370 tion in his patent?

A. I mean the same thing, with the exception of the balancing of the valves—his being double puppet-valves.

Q. Independent of that, you mean the same regulation of closing in both engines—do you?

A. Yes, in those particulars.

Q. Do you speak of the regulation of the closing, in the defendants' engine, in connection with the movement of their weight through the whole extent of its motion?

A. The whole extent of its motion is connected with the

corresponding movement of the valve, and consequently to 371
that extent it acts as a regulator.

Q. Then I understand you to mean, by regulation of the closing, the entire movement of the valve in its passage to close the port?

A. Yes, in connection with the fact of the movement to trip, which permits it to take up such action.

Q. Now, sir, in reference to the slam or jar in the defendants' apparatus, would not the apparatus of the defendants work just as well if the connection with the weight
were a loose connection—a chain—instead of being a rigid 372
one?

A. Well, I doubt if it would; I think there is more difficulty in imparting inertia to a great number of pieces, and getting up regularity of motion, when so applied, than to a rod; I think the difference, however, is quite unimportant, practically; but that such a difference does exist, I feel confident.

Q. Is it important, practically, whether you have a loose connection or a rigid one?

A. Not so far as the falling of the weight goes. 373

Q. Now, if you should operate Corliss' with a loose connection there, would there be any slam or jar transmitted to the parts that lie on this side of the loose connection?

A. Yes, sir; it would be imparted through a thousand pieces impinged upon each other; as striking a row of billiard balls would part one from the other end of the row.

Q. If the connection is entirely loose?

A. Yes; they become tight the very moment that bodies commence to fall, for they are sustained by each other, and
hence relatively are subject to receive any momentum ap- 374
plied to any one of these pieces.

Q. If the connections are loose, and the weight should strike a solid body below, in its fall, would not the connections slacken up immediately?

A. Yes, after parting with the blow—after diffusing the momentum.

Q. How much jar or slam would there be in that case; would it amount to anything practical?

A. Yes; and it would be carried from the parts sustain- 375
ing the dash-pot as well as through all the other parts; and such a chain would practically meet with difficulty, but not for the mere purpose of falling; when I stated that it might practically be used, it was in reply to your direct question as to its office of falling, and not as to its entire office as part of this machine.

Q. Now, practically, if the connection was a loose one, and the weight should fall against a solid substance, would not the entire effect be expended upon the weight and the substance?

Mapes X

376 A. I think the speed with which this arm to which the rigid shaft now attached to the weight is connected—this arm itself would exercise a momentum, an absolute momentum action upon this valve-stem, and, in so doing, no matter what might be the width of the bearing where the valve is, or where the prolongation that forms the trip is, still, a blow there, which would be collateral with the blow of a hammer, would alter the parallelism of the face of that valve, as compared with its seat, and, doing so at each revolution, at the same point or space, would, by a succes-
377 sion of such minute momentums, arising from the mere difference of the parallelism, eventually abrade that valve in a line, and thus destroy its usefulness.

Q. You think, practically, it would not be operative?

A. Practically, it would not be operative. If the momentum were not diffused, the harm will arise from the same offence to natural laws that will occur by loosening the plug to a cock, by the mere momentum of a blow with a hammer, instead of using a continued force or sliding the surface. If the plug of a cock should be stricken down in
378 the same direction as often as occurs in the revolution of an engine, that plug would have a flattened line on the side against which it impinged or altered its direction from such momentum or pulsation; and, if the space between that plug and the barrel in which it turned should be supplied with a lubricating material, which, after a while, would become charged with oxides and abrade the metal, the quality of the surface so impinged upon would be altered by these oxides being forced into that abraded part, which,
379 from its distance from the plug, would continually segregate these materials, and permit its being impinged upon its surface, forming a china-like ridge upon that part; and, to do away with that difficulty, in common with the other I have described, the dash-pot or its equivalent becomes necessary.

Q. I would like you to take the model of Sickels' apparatus, and tell me whether that would operate without a rigid connection between the plunger and the valve?

A. As to the matter of falling, yes.

380 Q. Will you please answer my question. Would that be an operative apparatus, with a loose connection between the plunger and the valve?

A. I think it would not be efficient.

Q. Could it operate at all?

A. Yes.

Q. How can that operate, if you have a loose connection? How would you prevent the valve from slamming, suppose it to be hung below, as it is now?

A. I suppose, sir, that if the lower part in this cylinder

should be a chain, the slam would not be arrested so tho- 381
roughly; it would require the blow to be received at a distance before the valve reached, greater than the play of each link of the chain; the upper connection might be a chain, but the lower one could not, to be practically useful.

Q. The upper one could be a chain, when the dash-pot is below?

A. Yes; the lower one could not, to be practically useful, but, theoretically, the slam might be materially abridged, even through a chain.

Q. Theoretically? 382

A. Yes.

Q. But not practically or perceptibly in the working machine?

A. I think perceptibly in the working machine.

Q. So as to make a practical apparatus?

A. No, but it would be abridged; the falling weight arrested upon the end of a chain will abridge the continuous action of that chain—its downward tendency—by checking its momentum.

Q. I think I understood you to say that you find Sickels'
apparatus so arranged as to cut off at any desired part of 383
the stroke?

A. Yes.

Q. It is so described?

A. Yes, sir.

Q. Can Corliss' machine effect that object?

A. Yes.

Q. In what way, sir?

A. In the same way that it is arranged here; he may arrange his trip to take place at any part of the stroke he likes.

Q. How so? 384

A. By an alteration of the position of the parts; you cannot do it beyond half-stroke in his machine, but you can in *this*.

Q. Can Corliss cut off beyond half-stroke, as his apparatus is arranged?

A. Yes, by a movement of this stop or standard.

Q. Can Corliss, within half-stroke, cut off at any desired point within that half-stroke?

A. Within any part that would be desirable for practical 385
purposes, I think he can.

Q. How will he do it?

A. He will do it by altering the arrangement of this stop, so as to trip at a different point.

Q. Without any alteration—I speak of the running of the engine, as it is constructed?

A. I do not think he can.

Mapes x

386 Q. Mr. Sickels can?

A. I think he can.

Q. Is it not the fact that Sickels can cut off at any desired part of the stroke, by the arrangement that he has there of the standard and set screw for the purpose of fixing the position of the wedges or inclined planes?

A. Yes, and the difference between it and the arrangement as there expressed, is merely an adaptation of the
387 plan of Sickels; but, for want of the same position, arises that inferiority of ready action.

Q. Now, sir, I think you told us, yesterday, that in Mr. Corliss' apparatus you found the inclined planes or wedges divided up into parts, instead of being resident at any one point. Will you please to explain what you mean by that?

A. Here, sir, in Sickels' apparatus, we have an inclined plane on this stop, which, in its statical condition, you can see is an inclined plane in figure; there (in Corliss' model) you have the inclined plane upon the surface of the moving
388 bar, which becomes pertinent to the same use as this inclined plane, at different points of its action, and a stop is used, against which it is impinged, so as to permit the wrist-plate to change the condition of the inclined plane, so as to permit the prolongation of the valve-stem to escape; therefore, I should say that that inclined plane is to be found resident in the relative position of all those parts; we see an inclined plane in one part, as it changes its position, but it is not that inclined plane alone that actuates the whole trip-
389 ping action.

Q. You are unable to put your finger upon any particular part of the apparatus which you call an equivalent for the inclined plane?

A. Oh! no, I can do that very readily.

Q. I understood you to say it was divided up into several parts?

A. I did, but they are so closely connected that one finger will cover the whole of them; this lifting rod, (illustrating on Corliss' model,) it will be perceived, has an upward and a wheel-like motion; I speak of the lifting rod that moves towards the wrist-plate, and consequently the space that it
390 described between its present position and the position it will assume in a moment would make an inclined plane; but, really, during its revolution it is arrested in performing that figure of an inclined plane, which would open the point of the V, by this stop, and hence the figure of the inclined plane, as formed for pertinent purposes, is resident between *that* surface and *this* surface, and the consequent change of position of *this* part, and hence acts upon this tripper, held to its position by the spring below.

Q. At the time the trip takes place, or, in other words,

Lever wedge

at the time the stop impinges against the connecting rod, is 391
there any wedge-action or inclined plane action to cause that trip?

A. Yes; it is the assumed figure of the wedge, the highest point of which is represented by the then position of the lower end of this stop, that lifts this connecting bar, and permits the valve to trip.

Q. I understood you to say that you never had examined the working of any of Corliss' engines?

A. Never with a view to these points.

Q. If those who have examined them accurately and 392
carefully should say that the action of that connecting hook in crowding off the catch, to make the trip, was solely that of a lever upon its fulcrum, without any inclined plane or wedge principle, would you be of opinion that their practical observation was better than theory?

A. I should be of opinion that the engine was not like this model, and their assertions to the contrary would be like the assertion of any individual who maintained that two and two made five.

Q. You have examined that model sufficiently to satisfy
yourself that there is a wedge action? 393

A. Perfectly.

On being re-examined by *Mr. Keller*, the witness, James J. Mapes, testified as follows:

Q. As a mechanical instrument for disengaging a catch in machinery, are there any equivalents for the wedges or inclined planes?

A. Oh, yes, sir! but they are modifications of it; every cam would be an equivalent.

Q. Can it be done by a lever as an equivalent?

A. No, I think not strictly as a lever; it ceases to be so 394
in that action.

Q. Suppose *that* (exhibiting model of a tripping action) to be the valve-rod, and *that* a catch, and *this* the adjustable stop, upon what principle does it operate?

A. It is removing the trip, and permitting the valve to fall by its weight.

Q. Removing the trip by a lever or wedge action?

A. Well, sir, I can find a wedge here in that action, or
inclined plane. 395

Q. Now, I would ask you, as a question of mechanics, whether a lever action of any sort can take place without generating the form of a wedge?

A. No, I think not; I think the wedge is a consequence of the action of the lever; the figure must be produced.

Q. Do you find in *this* a substantially different combination, or a substantially similar combination to that de-

Mapes a ...

396 scribed in Sickels' patent for effecting the trip in the valve?

A. It is substantially the same; the difference is only formal.

Q. Do you find a spring in *this* for restoring the catch?

A. I find a weight used as an equivalent for the spring.

Q. Now, sir, will you step around to Corliss' model. If you draw a line from the position which this wrist will occupy at the end of its upward motion, where it is in contact with the surface of the lifting rod, and project that line beyond, where will you find the wedge which disengages
397 the catch?

A. You will find it in the figure resident here, (illustrating it,) in the form of a V.

Q. Now, with reference to the adjustment of the cut-off, so as to cut off at different parts of the half-stroke, I did not understand your answer clearly in the cross-examination; do I understand you to say that it cannot be adjusted to cut off at any portion of the half-stroke?

A. No, but that it had not the same facility of arrange-
398 ment for such cut-off as *there*, while the machine was in operation.

Q. The question was confined to that?

A. Yes.

Q. While the machine was in operation?

A. Yes.

Q. Now, sir, I will ask you, taking this model as it is here, and disconnecting *this* rod entirely—taking this rod with its inclined plane resting upon the stop, and disconnecting the rod, or taking away the governor, having merely
399 *this* piece—I will ask you then whether this engine (Corliss') can be regulated to cut off at any portion of the stroke with the same facility as Sickels'.

A. It can, if you have an arrangement for the stopping of *this*.

Q. What is it in this machine that regulates the position of these stops?

A. It is a part of this bar that is brought in contact with the stop, so as to regulate its position; before the apparatus of Sickels', governors were used to regulate the cut-off.

400 Q. I am leaving out altogether the governor; I am taking this apparatus, supposing the connection to be broken *here*, and *this* rod to be under the control of the engineer; now I want to know whether this is capable of adjustment, to regulate the adjustment at any portion of the half stroke, as in the Sickels' engine?

A. Precisely, when under that arrangement; it would enable the engineer to do just what he could do *there*, by moving the stop upon the permanent standard, so far as regards regulating up to the full length of half stroke.

Q. Now, would it require the exercise of invention to apply the set screw to hold *that* rod in any position required? 401

A. I think not, but merely the exercise of mechanical skill.

Q. I understood you to state that in this arrangement of the defendants', as well as in Sickels', the valve is closed entirely by the falling of the weight; now, so far as regards the arresting of the valve at the time that the port is closed, what is the instrumentality employed to regulate that closing? 402

A. The dash-pot and its appurtenances.

Q. Then the dash-pot, I understand you, is the means of regulating the point at which the valve shall close?

A. No; regulating the point at which the weight shall be arrested, to prevent its passing beyond the mere covering.

Q. Now then, sir, is the dash-pot, in that view, a means of regulating the motion of the valve, or is it the means of regulating the closing of the valve?

A. It is the means of regulating the closing.

Q. Now, sir, in this arrangement, is there or not a necessity, when the valve is closed, of bringing the lifter back to its original position, with reference to its re-engagement with the lifting mechanism, at the next stroke of the engine? 403

A. Yes.

Q. Now, sir, if the arm of this valve should be connected with a weight by means of a chain, would that ensure the bringing back the position of the lifter to its right place, to re-engage at the next stroke.

A. No.

Q. Now, sir, in this arrangement of Mr. Sickels', if you should remove the dash-pot entirely, and place a solid plate of metal below the valve-stem, so regulated in its position that, on the descent of the valve, the lower end of the valve-stem would come in contact with that plate, at the same time that the valve reaches its seat, would the slam be on the valve or on the plate struck with the valve-rod? 404

A. It would be on the plate; but such rigid contrivance would not do away with the practical difficulty of the slam.

Q. I want to know whether, in that case, of the plate below and the valve-stem receiving the shock, the valve would not slam as effectually, and be as effectually injured, as if the valve itself struck, without having the plate below? 405

A. Not as much injured, but it would be injured; if you divide the slam upon three faces instead of one, you, to a certain extent, lessen the chance of accident; but the precise parallelisms that are maintained by the valves in position, are not to be approached by the exact mechanical contrivance, but to be found by the gravity of the parts

406 setting into each other; and hence the line of abrasion is not a line within exact mechanical accuracy; and it is for that reason that an oscillating valve like the defendants', that has a width, and acting upon the edges, would abrade the surface by a blow upon its shaft, upon the valve stem.

Q. You were asked yesterday, with reference to the action of the dash-pot upon the arrangement of the defendants and that of the plaintiffs, and you stated that in the Sickels' arrangement the valve must be arrested by the dash-
407 pot immediately before the closing of the valve, and that in the defendants' it need not be, but is better to be stopped at the time the valve closes its port. Now, sir, if the valve be closed in the defendants' arrangement, after it has closed the port, what would be the consequence upon the working of the engine?

A. If the valve be closed?

Q. If the valve be arrested only after it has closed the port, what would be the consequence upon the working of the
408 engine?

A. "Only after?" I do not understand your question.

Q. The valve in Sickels' engine must be stopped at the time of the closing of the port; you stated, yesterday, that it was not absolutely necessary in the defendant's engine that the valve should be arrested immediately at the time the port is closed, but that the valve may move beyond, and then be stopped. What would be the consequence, upon the working of the engine, to have the valve move beyond what is necessary to close the port?

409 A. There would be a waste of power and unnecessary trial of the parts, without pertinent use.

Q. Is there any way of accomplishing the same result in the puppet-valve?

A. Oh, yes!

Q. In what way?

A. By the use of rings.

Q. What would be the consequence of using rings in puppet-valves?

A. The consequence would be that the valve would shut before it found its seat—it would arrest the delivery.

410 Q. Would it occasion a loss of power in the working of the engine?

A. Yes; because during the time it was passing there, there would be a wire-drawing of the steam.

Q. Now, sir, in both these engines, if you withdraw the stops in this of the defendants—if you lift up the stop, so that the lifter-rod will not come in contact with it during any portion of the stroke, and in Sickels' you move the sliding-piece so that the spring-catches will not come in contact with the stop, what would be the consequence upon the working of the engine?

A. They will not cut off; they will work continuously, 411
as in the old engine, before its modification.

Q. Then the use of a stop to effect the disconnection of the parts is an essential element in the combination of both these engines?

A. Yes; in describing that dash-pot, yesterday, in the defendants' engine, I spoke of its meeting with a solid resistance when the plunger had fallen below the hole; I so used that term, in answer to a special question, being well aware at the time that, to prevent recoil, it was not a solid
compression of the air, but that there must be a slight es- 412
cape through the annular surface, which practically must occur in a large way, to permit the falling of that piston.

Q. There is then, if I understand you, a slight passage for the air, after the piston descends below the aperture or outlet?

A. Yes, particularly when impinged upon by a piston falling at that speed.

Q. You were asked, yesterday, whether the rotating valve on the defendants' engine ever raises from its seat
and slams thereon; I want to know whether that ever can 413
occur, and the reasons why?

A. That which practically is collateral with it can occur; I have before remarked that this valve may be supposed to represent a section of the plug of an ordinary stop or water cock, and that, if, instead of using the plug of that cock for continuous turning, to perform its office, you should remove it with the blow of a hammer, which would have a tendency to make it bear more at the point and less at the heel, or more at the heel and less at the point, at one time than at
another, and that, by an absolute momentum, as in the 414
blow of a hammer, it would abrade a line upon the surface of the barrel of that cock, and would render it inert after a time; that is collateral with the harm done by the slam; and this arrangement prevents this momentum being thrown upon the valve, as it would be if it were not for the dash-pot put *here*. The action of this falling weight upon this valve-stem, at its centre, would be the same as the blow of a hammer upon the centre of this valve-stem; it would make it
vibrate, no matter how rigidly this bar is fixed. The blow 415
of a hammer, in contradistinction to any continued force, would pulsate to the fibre of the metal, so as to alter its parallelism for all practical purposes; the various portions of the dash-pot in this machine show the necessity of its use to these parts.

Q. Cannot a series of plates of metal, placed upon each other, be reduced in thickness by striking the upper one—the whole mass being placed upon an anvil?

A. In the ordinary beating of gold-leaf there are many sheets one above the other, and the blow upon the upper

Mapes re X

416 sheet receives a momentum which diffuses itself through the whole mass, and beats the whole pile; that is the way in which gold-leaf is reduced; and this is precisely as the slam would be diffused through the parts of that engine, connected with each other, if it were not for the arrangement of the dash-pot.

On being further *cross-examined* by Mr. Blatchford, the witness, James J. Mapes, testified as follows:

Q. In regard to the lap of the valve beyond the point where the port is closed, I understood you to say that you
417 saw nothing in that but a loss of power, and that, in the puppet-valve arrangement, an equivalent for this lap was the use of a check-ring. In that connection, sir, I want to ask you whether, in engines having slide-valves, you see no advantage in that lap, for the purpose of effecting the very rapid closing and the very rapid opening of the port, for the purpose of avoiding wire-drawing?

A. Of what lap?

Q. Of the lap in the slide-valve, in order that the valve may rush by rapidly, and thus prevent wire-drawing of the steam, by closing suddenly?

418 A. Certainly, there is an advantage in the travel of the slide-valve, with such a degree of rapidity of the parts in its motion, as would give the most rapid delivery at the time of the greatest opening of the port.

Q. In that view, is a check-ring puppet-valve an equivalent?

A. I do not think it is in that case.

On being further *re-examined* by Mr. Keller, the witness, James J. Mapes, testified as follows:

Q. I understood you to state for that purpose, that a check-ring in a puppet-valve is not an equivalent. When
419 the puppet-valve begins to move up from its seat does it not move at its minimum velocity in an engine?

A. Yes.

Q. Does not that motion go on accelerating for some time?

A. Yes.

Q. Now, sir, if a check-ring be placed around the valve, so that the steam will not escape through the port until after the valve leaves the check-ring, will not the valve be moving faster at the time it leaves the check-ring than when it leaves the port?

420 A. So far as that ratio of speed goes, they are analogous.

Q. In the use of the check-ring, at the time the valve gives admission to the steam, is not the valve moving faster than at the time it leaves its seat?

A. Under that view of the subject there is an analogy; I had overlooked the position of the puppet-valve when so arranged with the check-ring, in that part of its travel.

Hibbard

The plaintiffs here rested their case.

The case was then opened to the jury on the part of the defendants, by SAMUEL BLATCHFORD, ESQ., and the court then adjourned to December 28th, 1854, at 11 o'clock, A. M. 421

DECEMBER 28th, 1854, 11 o'clock, A. M.

Thed efendants called as a witness, WILLIAM C. HIBBARD, who, having been sworn, wasexamined by *Samuel Blatchford, Esq.*, on e of the counsel for the defendants, and testified as follows:

Q. Where do you reside?
A. In Boston.
Q. What are and what have been your pursuits in connection with mechanical science? State fully what have 422
been your means of acquiring a knowledge of the subject.
A. My present occupation, for several years past, has been that of a mechanical engineer and draughtsman; I have spent all my life in mechanical pursuits: I am now mechanical engineer of the Atlantic Works at Boston; formerly I did business in the way of arranging and preparing specifications for patents.
Q. As draughtsman?
A. Yes.
Q. Have you ever had any acquaintance, practically, 423
with steam-engines?
A. Yes, that is the business which we follow now; it is a branch of mechanics that I have had more experience in than any other.
Q. Have you read the patent and examined the specification and drawings of the patent granted to F. E. Sickels, on the 20th of May, 1842?
A. I have.
Q. So that you understand the same?
A. I think that I do.
Q. Will you examine this small mahogany model of the 424
plaintiffs' apparatus, and state whether it is substantially according to the description in that patent?
A. I believe it is substantially correct; but I should think the black model which I have seen in court shows the external form of it more accurately; this mahogany model shows the interior construction of the dash-pot better than the black model does.
Q. From your acquaintance with and knowledge of steam machinery, what was the usual way of acting upon the lifter of the apparatus described in Sickels' specification, at the time this patent was taken out, in May, 1842? He says that the valve-stem "is to be raised by the lifter E, "which is to be acted upon in the usual way."

Hubbard

425 [Witness pointed out and explained upon models the mode of acting upon the lifter.]

Q. How is the lifting-rod moved—by what mechanism, in connection with the main eccentric?

A. By a rocking-shaft.

Q. Will you point out the combination of apparatus that you find in the plaintiffs' specification for the purpose of effecting the more readily cutting off of the steam?

A. The invention described in the patent, which was applied to this valve and valve-gear, then in common use, was,
426 instead of fastening the valve-stem permanently to the lifter, usually by a notch above and below it, to connect it, by the combination of a spring and an adjustable sliding-piece, provided with an inclined plane, so that when the valve was in its movement upward or downward, as might be required, it should be disconnected from the lifter, and allowed to drop, while the lifter continued its motion upwards, or else that it went upwards and commenced the movement downwards, and then detached, and the valve
427 fell away from the lifter, descending with a more rapid motion than the lifter itself descended; by means of which the valve could be tripped at any portion of its upward or downward stroke, substantially, and thus the cut-off be effected at such points as might be determined.

Q. Will you name the parts that compose the combination of that apparatus?

A. The parts described in the patent are, the valve-stem B; the spring F, on the lifter; the adjustable sliding-piece I, with its wedges or inclined planes, and their immediate
428 appendages; I mean by appendages, the standard and set screw which hold the sliding-piece in a proper position to act. By means of that combination the detachment is effected; and that I understand to be the entire of that part of the invention.

Q. Upon what does the point at which the detachment is effected depend; the point in reference to the stroke of the piston?

A. At the point at which the adjustable sliding-piece is fixed, in connection with the stroke of the piston upward and downward. If it is required to detach before half-
429 stroke, the inclined planes are so placed as to open the springs, which spread out from the notch upon each side of the valve-stem, during the upward movement; but if it is required to cut off beyond half-stroke, this sliding-piece is reversed, and the springs engage with a different side of the inclined plane, and separate in the descending movement. If it were required to cut off at either of these points, engineers would adjust the sliding-piece accordingly.

Q. Could it, or not, be adjusted to cut off at any point of the entire stroke.

A. No, strictly, no; the shortest motion of cut-off would be to place the wedges so low as to be in contact with the springs when they commence to rise; at the exact point of half-stroke it would be difficult, because the valve has come to a state of rest. 430

Q. As a practical thing?

A. You can cut off at nearly every point during the whole stroke.

Q. Have you examined this model of the engine, used by Youngs & Cutter?

A. I have.

Q. Have you seen that engine in operation? 431

A. I have.

Q. Have you seen other engines constructed upon the same principle as that?

A. I have.

Q. Other engines known as Mr. Corliss'.

A. I have.

Q. Have you seen them operate?

A. Yes.

Q. And examined them carefully?

A. Yes.

Q. I mean other engines, constructed according to Corliss' plan, besides the one used by the defendants? 432

A. I have.

Q. So that you understand the principle of construction and the mode of operation?

A. Yes.

Q. Now, sir, in your opinion, as a mechanical engineer, is the construction, arrangement or combination of the apparatus used in the defendants' engine, for more readily cutting off steam, substantially identical with the construction, arrangement or combination of the apparatus 433 described in Sickels' specification for that purpose?

A. It is different, in my judgment.

Q. Will you be good enough to point out the parts of the defendants' combination which are employed for that purpose, and to specify in that connection your reasons for the opinion that they are substantially different from the plaintiffs'?

A. My reason for the opinion that they are different is, that, as I understand it, there is not one element in the defendants' which goes to make up the combination which is 434 described in Sickels' patent as constituting the improvement which was added to the puppet-valve and gear then in use; the difference starts, as I conceive, from the commencement, that is from the valves that are employed to admit and control the action of the steam in the engine.

Q. Point out the valves that admit steam into the cylinder in Corliss' engine.

Hubbard

435 A. The valves are upon this side—(pointing them out.) The valves used in Corliss' engine are of the kind known as slide-valves, instead of that form of valves which move to and from their seats, which are called puppet-valves, and some other description of valves which it is not now necessary to mention; and Corliss' is a peculiar form of slide-valve, which slides in the arc of a circle, instead of sliding in a plane, which is the more usual form in engines ordinarily in use. The small model, or piece of model, that I have here, represents the interior of the valve-box, and the
436 form of valve that is used in it; this valve slides backward and forward upon a curved seat, and it opens and closes the port into which steam is admitted, in a manner analogous to the ordinary slide-valve, which draws straight upon a surface, and opens the port in a similar way. These sliding or turning valves—sliding in the arc of a circle—can be actuated by a rock-shaft, placed in the centre of that circle, without the usual appendage known as a valve-stem; for instance, if the sliding-valve slide within a steam-chest, it would require some rod to pass within the steam-chest,
437 through a stuffing-box, to actuate it; that is called a valve-stem, and is necessary to the ordinary use of slide-valves, and also of puppet-valves. This peculiar mode of actuating the valve in Corliss' machine is due to the fact of his using valves sliding in the arc of a circle, which permits that peculiarity in the arrangement of the valve-gear; the motion of the valve is in the direction of the arc of a circle, and not lengthwise; it slides in a curve, instead of sliding in a right line. That peculiarity in the structure of Corliss' valve and of its seat gives character to the whole valve-gear
438 which actuates it. The four horizontal shafts in Corliss' model are the several rock-shafts which actuate the four valves; that is, the two inlet-valves and the two exhaust-valves; the upper ones are the steam-valves, and the lower ones the exhaust-valves; the rock-shafts pass through stuffing-boxes into the steam-chest, and the large rectangular part of the shaft lies in a groove in the valve, and causes it to slide in the arc of a circle, so as to give it movement, to uncover the port and close it again at the proper
439 time. The motion to work the valve is derived from the eccentric upon the main shaft, constructed in the usual way, and from that communicated to a peculiar kind of rocker, technically called a wrist-plate, which is, in effect, four rocker-arms or cranks; it is the same in effect as four cranks set at different points around the centre, with another crank or arm to receive the motion from the eccentric; by the back and forward motion imparted by the eccentric, it will be perceived that each connecting rod which connects this wrist-plate with a rocker-arm upon the rock-shaft of the valve, is made to come near to what is known in mechanics

as its dead point, while the wrist-plate is yet in motion; 440
the purpose of this combination of the rods, wrist-plate and rock-shafts with the valves, is, in effect, to give a rapid movement at the opening and closing of the valves. After the valve has closed the port it should have a slow movement, when the lifter is at rest; while thus inoperative, it is the purpose of the valve-gear to give a small motion, and this arrangement effects that object.

Q. At the time the valve is closed?

A. After it is closed; and, at the time it commences to
open, it begins a movement in an opposite direction from a 441
state of rest, and goes to a rapid part of its movement before it becomes operative to permit the escape of steam, thus preventing the result which has been heretofore described as wire-erawing. (Witness illustrated the movement on Corliss' model, and continued:) The valve, it will be perceived, is moved for a considerable distance, and its motion, at the throw of the crank, becomes rapid, opening its port with a rapid movement, all the movement of the valve beyond that being simply to use up the time; it is
thus put in movement without any shock—by a perfectly 442
noiseless movement of the mechanism. To effect the further object, then, of freely admitting and permitting the ingress and egress of steam—to effect the purpose of a cut-off, so as to work steam expansively, (that is arresting the influx of steam at any required point in the stroke,) the hook-rod in Corliss' engine is made to engage with the rocker-arm by means of a catch upon that arm being forced against the notch in the rod, by a spring underneath the rod. In
the movement of the rod backwards and forwards it has a 443
longitudinal movement, and also a lateral movement, which it derives from the peculiar nature of the wrist-plate from which it receives its motion. By placing the brass slide in Corliss' engine nearer or further from the hook-rod, that rod will impinge against the slide sooner or later, and will therefore effect the detachment sooner or later, and thus cut off steam at a longer or shorter portion of its stroke; the brass slide, which serves as a fulcrum for the hook-rod, is placed in position by a rod above it, provided with two
inclined planes, one for each end of the engine, which rod 444
is connected with the governor, or rather is placed in position by the governor, and thus, being under the control of the governor, determines the point at which the cut-off shall be effected by the velocity of the engine itself.

(*Mr. Keller* submitted to the court whether it was proper for the defendants in this case, to go beyond the apparatus for tripping the valves, and arresting or governing the closing of the valves.

The court allowed the testimony.

445 *Mr. Keller.* Then, your Honor, shall we not have a right to rebut?

The Court. Certainly.)

Q. Explain the whole action of the governor, in connection with the detachment?

A. The governor, through the intervention of the mechanism shown upon the model, has the effect of placing the brass stem or stop which determines the point of cut-off in a position according to what the velocity of the engine
446 requires; the effect of that, in the operation of the steam, is, in general terms, to make the engine, under all conditions of tension of the steam and of the work upon it, act with a maximum expansion; you get the greatest amount of expansion that can be got in an engine; in that respect it produces an effect which cannot be attained by regulating a cut-off of steam by separate devices; therefore it is of great advantage to use it with a maximum expansion.

Q. As a mechanical engineer, in Mr. Corliss' engine, the governor being connected with the cut-off valves, and no
447 throttle-valve at all being used, what object, in the economical use of the steam, do you see developed in that apparatus?

A. The object which I stated before—that is, working steam under all conditions of work upon the engine and of pressure in the boiler, at the maximum pressure which you can derive from the steam in the boiler. The greater the amount of expansion, (the amount of expansion being comparatively a measure of the useful effect derived from the steam,) the greater the economy in the working of the en-
448 gine within ordinary limits.

Q. As a practical question, in the operation of Corliss' engine, have you tested it by any means?

A. I have made diagrams of the operation of the engine, when working.

Q. This engine of Youngs & Cutter's?

(The plaintiffs' counsel objected to this question, and the objection was sustained by the court, and the question was overruled.)

Q. In the defendants' engine, as arranged in connection with the governor, how do you find it constructed and
449 adapted to regulating the cut-off according to the varying load or work that it has to perform, and according to the varying pressure of the steam?

A. In general terms, it is by combining the governor with the valve-gear, so that it shall place the stop in a position to impinge against the hook-rod, which position governs the point at which the cut-off will be effected.

Q. What will that point at which the cut-off shall be effected, depend upon ultimately?

A. It will depend upon the velocity of the engine.

Q. What will that velocity depend upon? 450

A. It will depend upon two causes, the varying tension of the steam and the varying load upon the engine.

Q. Show minutely, upon the mechanism of Corliss' engine, how an increase or reduction of load operates, through the balls of the governor, and through the other mechanism, upon the point of cut-off.

A. The regulator or governor is an instrument by which the position or height of the plane of revolution, as it is called, of the balls, depends upon the velocity with which they rotate, and that again depends upon the velocity of 451
the engine, because the governor derives its power from the engine. If the engineer wishes to run forty, the governor is so connected with the engine, that when revolving at forty, the plane of revolution shall be so high as to put the brass stem or stop in a given position, which admits steam sufficiently long to give the engine forty revolutions a minute. If the tension increases the velocity of the motion of the engine, the plane of the balls will rise, and, acting on the wedges, will move them so as to press down the stop, and cause it to impinge sooner against the hook rod, and produce a detachment sooner, and thus a short point of 452
cut-off. The reverse takes place when the movement becomes slower.

Q. I now revert to the first question which I put to you, and that was in regard to combinations connected with the detachment in the two engines,—whether you found those combinations of apparatus in the two engines substantially different or substantially alike. You said you found them substantially different. Please go on and give your reasons why you deem them substantially different.

A. I gave as my reason then, that I do not find, as I con- 453
ceive, a single element which makes up the combination described in Sickels' patant, either in form, or, as I conceive, in function. The similarity between the machines is this: that they both effect a detatchment of the valve from the mechanism that opens it; but the means by which that detachment is effected I conceive to be substantially and widely different, and a differen e depending, primarily, upon the different kind of valve used in connection with the engine, and so the same distinctive characteristics are car- 454
ried through the entire valve-gear.

Q. I will ask you to direct your attention to the action of the wedges or inclined planes in the plaintiffs' apparatus, for the purpose of effecting the detachment, and state whether you find any action of that kind in the defendants' apparatus?

A. I do not. I do not see any thing that answers to it, or what is, mechanically, the action of an inclined plane.

Q. Explain the action of the connecting rod.

Hubbard (D)

455 A. The movement by which the detachment is effected is the lateral movement of the rod, in a downward direction, passing over, or under rather, and moving around the brass stem as a fulcrum, in connection with a longitudinal movement which opens the valve. It has a peculiarity imparted to it by the wrist-plate and the rockers, which control the movement at each end, causing it to be a swinging rod until it comes in contact with the fulcrum; it then vibrates over it in the manner of a lever, throwing the outer end, or end more remote from the wrist-plate, away from its rocker, the
456 rocker moving in the arc of a circle away from the rod, and thus the sundering of the connection is effected. There is no action of an incline there that I can perceive.

Q. In that connection, sir, I would ask you what effect has the fact that the connecting-hook is in different positions, and that the lines represented by its upper surface, at two of its different positions, would form a wedge; what effect has that in the business of detaching?

A. The fact that it stands in two different positions only
457 indicates that it has been moved from one to the other, and that it is the action of a lever. The mechanical definition of an incline is, that the impinging surface should move in the direction of its angle to its surface; it is merely, in this case, a change of position; it is another way of stating that it changes the direction of its motion; the stop being permanent, it moves in the direction of the impinging surface, and it is simply one surface moving over another; it is not the action of an incline, or any thing approaching it, in my judgment.

458 Q. I will call your attention particularly to what, in the plaintiffs' combination, is specified as a "spring upon the lifter," and ask you whether you find that, or any equivalent for it, in the defendants' apparatus?

A. No, nor anything that has any such purpose; one of the objects of the spring upon the lifter, in the plaintiffs' machine, is to give that flexible latch, (so made for the purpose of permitting it to pass the stop without detaching)—a latch on its return; there is no such purpose in the defendants' machine, nothing similar which effects the connection;
459 the only similarity is that there is a spring there which presses the parts together to engage them; there is some analogy in the mechanical action, but it is not the same thing, as I conceive.

Q. I understood you to say that in the defendants' arrangement there cannot be a cut-off beyond half-stroke. Will you show the arrangement upon the model?

A. You can cut off very near the point of half-stroke; it is not effected until the valve closes its port.

Q. Why is that? Show it in the defendants' apparatus.

A. It is because the hook-rod is moving in a direction

towards the wrist-plate only during the first half of the 460
stroke of the engine; the last half it is moving in an opposite direction, and it can only detach when moving towards the wrist-plate.

Q. I will now draw your attention to the apparatus described in the plaintiffs' specification, for the purpose of regulating the closing of the valves, and effectually preventing them from slamming. Will you tell us, from the model, what combination of apparatus you find described in the plaintiffs' specification for that purpose?

A. The apparatus employed by the plaintiffs, in 461
connection with puppet-valves, is a water reservoir, containing within it an adjustable cup, into which a plunger, attached permanently to the valve, is made to enter a short distance, the adjustable cup being immersed in water, or some other fluid which is equivalent to it; a portion of the water is enclosed within the cup, and there being but a small escape between the interior of the cup and the exterior of the plunger, the descent of the plunger can only be just in proportion to the rapidity of
the escape of the water; this cup is made to be raised or 462
lowered, so as to offer that obstruction to the descent of the valve at such point as is required in the working of the engine; if it falls with greater momentum, it will require to be checked sooner, and if with less momentum, later; the longer it cuts off before half-stroke, the higher the valve will be raised; the higher the adjustable sliding piece is set, the higher the valve will be raised before it detaches, and, therefore, the greater distance it will fall. Puppet-valves, which move in a direction at right-angles to their
seats, require considerable resistance to stop them, so that 463
they shall come down upon their seats without any injurious blow, and thus abrade the surface, and make them leak; the apparatus described in the patent is for overcoming that, by offering a determined degree of resistance, by means of the adjustable cup, acting with the plunger, and admitting that to be regulated, so as to make resistance at the point required for the working of the engine.

Q. Does that apparatus, so constructed, effect the two objects which are mentioned in the last question, namely:
the regulating of the closing of the valves, and preventing 464
them from slamming?

A. It would do that, if properly constructed.

Q. You have also noticed, in the operation of the defendants' engine, the working of the weight in the air-cylinder, in connection with the detachment and the closing of the valve—have you not?

A. I have.

Q. Will you state whether, in your opinion as a mechanical engineer, the apparatus in that connection in the

Hubbard

465 defendants' machine is substantially identical or not with the construction and arrangement of the apparatus in the plaintiffs' machine, for the purpose of regulating the closing and preventing the slamming of the valves?

A. I think they are substantially different combinations, arising primarily from the substantial difference in the operation of the valves with which they are connected.

Q. Will you give your reasons for your opinion that they are substantially different, both in regard to their construction and mode of operation?

466 A. The distinction in the nature of the valves is this: that the slide-valves never leave their seats; they simply slide upon their seats, changing their position, and still continually resting upon the same surface—that is, the surface of the valve remains continually with its seat, and therefore the valve can never come to its seat; and there is no possibility of making a valve slam unless it leaves its seat and approaches it. There is no combination of the dash-pot for any such purpose, in connection with the valves, as there is in the plaintiffs' machine; there is no
467 slamming to be prevented; there is no shutting to be retarded, that is, there is no necessity for checking the valve before it reaches its seat, because it does not leave it; the action of ths slide-valve depends upon the nature of the valve itself; in the defendants' machine the effect of the weight is to close the valve, after it is detached from the valve-gear, and the purpose of the air dash-pot is to permit the weight to come down to a state of rest without shock and without noise; it requires no nicety of adjustment as regards the closing of the valve; it is only neces-
468 sary that the gear should be stopped at such a position that the hook can engage with it the next time; if it stops a little short of this, by the action of the dash-pot, it is of no material consequence, provided it can be forced further, because the hook-rod pushes it further, until it comes to a position where it can engage with the hook-rod; its connection with the valve, and the purposes for which it is applied, appear to me to be substantially different from the other.

Q. In witnessing the practical operation of the defend-
469 ants' engine, did you notice the position of the weight, in reference to the hole in the side of the air-cylinder, at the time the port was closed?

A. I did, in connection with some other gentlemen; we took a series of measurements, in connection with a certain mark; the valve being enclosed in the engine, working, we could not see the valve itself, but a certain mark was made next the rocker; assuming that to be the point, where the valve was just closed, we took some measurements.

Q. What was the result? 470

A. Assuming that to be the closing point, the bottom of the weight was from one-half of an inch to five-eighths of an inch above the top of the orifice.

Q. When the port was wholly closed?

A. Yes; and it requires that to enable the rocker to move past the point of closing, to use up the time in the motion of the eccentric; when it is necessary to cut off short, then the valve should pass the port, in order that it may close with a rapid motion, as it makes no difference, in that construction of the valve, whether it closes the port or not, so far as any shock is concerned. 471

Q. Do you find, in the defendants' apparatus, any adjustable cup or secondary reservoir?

A. I do not.

Q In view of the use of the adjustability of the cup in the plaintiffs' apparatus, of which you have just now spoken, do you find any such adjustability in the defendants' apparatus?

A. I do not; there does not seem to be any use for it.

Q. What are the uses and offices of the falling weight in the defendants' air cylinder? 472

A. To close the valve, after the valve-gear has left it.

Q. What is the use and office of the air cushion in the cylinder of the defendants' engine?

A. To arrest the falling of the weight; to stop it without any shock, after it has closed the valve.

Q. In that construction, is it material at all whether the connection with the weight is a rigid or a loose connection?

A. Not the least.

Q. Have you seen the defendants' engine at work, with a loose connection substituted for the rigid connection? 473

A. Yes; one of the dash-pots had the rod removed, and a small piece of tarred line put in its place; it worked just as well.

Q. Was there any practical difficulty in the operation of the machine?

A. No; probably it would not be so durable.

Q. Did you see any difficulty in connection with the hooking on, when the loose connection was used?

A. No.

Q. Will you please to state, sir, whether you see anything in the defendants' apparatus, as compared with that of the plaintiffs, in regard to the effect of the pressure of the steam upon the valve? 474

A. There is this distinctive difference: by the peculiar action of a puppet-valve, the steam pressing upon its upper surface, even though balanced valves are used—(if balanced valves are not used, it is a question of material consider-

475 ation in the operation of the valve)—the increased pressure of the steam increases the momentum of the falling mass, that is, all that is connected with the valve. In the defendants' engine, from the fact that the surfaces are always in contact, any increase in the pressure presses the face of the valve and its seat further in contact, and produces increased friction; so that, in the working of the defendants' engine, as we saw it in operation yesterday, working with a line substituted for the dash-pot rod, the pressure of the steam upon the valve, after it has closed the port, in effect,
476 causes a retardation in the descent of the weight.

Q. In connection with the effect which you have just mentioned, as to the pressure of steam in the defendants' engine, do you find any similar or contrary effect of the pressure of steam in the plaintiffs' apparatus?

A. It seems to be directly contrary, so far as relates to the closing of the valve; in Sickels' the effect is to accelerate the moving of the valve, and in Corliss' to retard it.

Q. For all substantial purposes and uses, is or not water
477 regarded as an incompressible fluid?

A. As far as we use it mechanically, we call it incompressible; its degree of compressibility is so small that, mechanically, no use is made of it, so far as I am acquainted.

Q. How is it with reference to air?

A. That is very compressible; it is one of the "elastic fluids," as it is called.

Q. Is it known and spoken of as a compressible and elastic fluid?

A. Yes.

478 Q. Can the apparatus of the plaintiffs for the more readily cutting off steam, be used or not as a practical thing, except in connection with an adjustable cup or secondary reservoir, as described in Sickels' patent?

A. It must have an adjustable cup in connection with it; I think it might be put above instead of underneath it, but there must be the same rigid connection between the two, and the same adjustability between the two, to vary the condition of the cut-off; if the cut-off were to be changed to any extent, it would require the adjustment of the water-
479 reservoir.

Q. If you used the plaintiffs' tripping apparatus, without using the apparatus to check the descent of the valve, what would be the consequence in the operation of the machinery?

A. It would destroy it in a very short time if the valve were allowed to fall unobstructed; it seems particularly appropriate to the kind of dash-pot used, and to the employment of water, from the fact that water is supplied from the condenser, and from the fact that precision in the adjust-

ment of the point of resistance is necessary. A non-elastic 480
fluid seems to be indispensable to be used in that dash-pot,
because elasticity is not the property which is to arrest the
shock, but the escape of the water out of the secondary re-
servoir; and its rate of escape governs the rate of the descent
of the valve.

(The counsel for the defendants then offered to prove by
the witness, *Hibbard*, what was the state of the arts in
regard to the cutting off of steam in working the steam-
engine, at the time Sickels invented the improvements 481
covered by his patent; and also that apparatus for effecting
a cutting off of the steam at steam puppet-valves, in
working the steam engine, by detaching such valves from
the mechanism that operated them, and allowing them to
come to their seats by the force of gravity, or through the
falling of a weight; and also a water dash-pot and plunger,
to arrest the momentum of such falling weight, and prevent
the concussion and slam of such puppet-valve upon its seat
when closing in consequence such detachment, were known 482
and used, and had been described in printed publications
prior to the time when Sickels invented his said improve-
ments. This evidence was offered by the defendants for
the purpose of furnishing the court with information upon
which to give a proper construction to the claims of Sickels'
patent, and for the purpose of showing that the patent must
be construed to claim only the construction, arrangement, or
combination of the particular apparatus described by Sickels
in his specification for effecting the cutting off of the steam
in working the steam engine, by means of steam puppet- 483
valves, and to claim only the construction or arrangement
of the particular apparatus described by Sickels in his spe-
cification for preventing the slamming of such puppet-
valve upon its seat.

The counsel for the plaintiffs objected to the introduction
of the testimony so offered, and the court sustained such
objection and overruled such offer, and refused to allow the
defendants to prove what their counsel so offered to prove.
To such decision, and overruling, and refusal of said court,
and to each and every of them, the counsel for the defend-
ants duly excepted.) 484

The court then adjourned to December 29th, 1854, at 11 o'clock, A. M.

December 29th, 1854, 11 o'clock, A. M.

The *direct examination* of *William C. Hibbard*, a witness for the defendants, was resumed.

Q. I inquired of you yesterday, with reference to the operation of the defendants' apparatus, if the connection between the arm on the rocker-shaft and the weight in the

Hubbard B

485 air-cylinder was a loose connection instead of a rigid one, and you replied to the question. What would be the effect, in Sickels' apparatus, if the connection above the plunger were a loose connection?

A. It would render the dash-pot inoperative entirely; it would offer no resistance to the descent of the valve; the valve would go down with its full weight, from the pressure of the steam above it.

Q. That is, putting a loose connection between the plunger and the valve, in Sickels' engine, as the loose con-
486 nection was put, in the defendants' engine, between the weight and the valve?

A. Yes, sir.

Q. Are these parts of Sickels' apparatus, now exhibited to you, (DeLaine engine,) of the working size, calculated for an engine?

A. I suppose they are; apparently they have been used.

Q. Will you be goood enough to show, in that apparatus, the operation of the detachment; show how the operation of the mechanism is effected?

487 A. The parts within the casing which represents the valve-chest, are the two discs of the valve; there is a balanced valve, as it is called, or double beat valve, in this construction, which opens an aperture above, and also one below the steam passages, one acting against the other; it is represented with an attachment on the valve-stem, in which is an annular notch or groove around, into which this latch upon the lifter engages at the proper time; the lifter is here shown, and within a hole through it there is a lifting rod, rising and falling, and imparting a corresponding
488 motion to the valve when engaged with it.

Q. Explain how the latch is crowded off.

A. By the side of the lifter is fixed a standard, and upon that a conical piece of iron, the surface of which forms an inclined plane with the direction of motion which the lifter makes in rising; the lifter rises and impinges against the conical piece, and that, being inclined, forces the latch out of the notch, and permits the valve to drop; the latch is to be held permanent, with a rigidity sufficient to press it into
489 the notch, which requires some force when the valve is heavy.

Q. Do you see anything upon the inclined plane, or the latch there, that shows that that apparatus has been in actual operation?

A. Apparently it has been worn.

Q. Look upon the inclined plane also, and point out to the jury whether there is any part which indicates that it has been worn?

A. The part against which the latch impinges, when

rising, has the appearance of being worn; it has been 490
changed around in one or two places; when one surface is worn out it can be changed so as to present a new surface.

Q. What is the cause of wear upon the inclined plane and latch?

A. It is the friction of the latch with the valves hanging upon it; the latch has to be thrown out of the groove, under the pressure of the weight of the valves upon it; it is the
friction of the parts; it has also to overcome the pressure 491
of the spring which causes the latch to engage with the stem.

Q. What species of latch do you call it, in that construction?

A. I do not know that I can answer that; its action is similar to a common latch.

Q. Is it a latch like the apparatus represented in the specification of Sickels' patent, and shown upon the small
model? 492

A. I do not think it is; it is not intended to produce the same effects.

Q. Wherein does it differ in regard to construction or effect?

A. It would act quite similar to it so far as concerns detachment upon mere rising; but the invention of Sickels, as I understand it, is to make such a combination of devices
for attaching the valve-gear to the stem, that it can be de- 493
tached both in ascending and descending, and for that purpose it requires a flexibility in the spring or latch, which would permit it to pass the incline; by bending inward, and then resuming its first position, it engages with the inclined plane in descending, to open the valve in the latter part of the stroke.

Q. In those working parts do you find any flexibility
which would be required for cutting off beyond half-stroke? 494

A. None at all; it is evidently not designed for that purpose.

Q. Will you be good enough to state what the effect upon the steam is, of the use of a throttle-valve?

A. The effect is to reduce the tension; after the steam has passed, the difference in tension is just equal to sufficient pressure to force it through the orifice at any given
velocity. 495

Q. What do you mean by tension?

A. So many pounds to the square inch.

Q. Pushing force?

A. Yes; the force it exerts against any given surface; so many pounds of pressure exerted upon a given inch of area.

Q. Now, sir, in connection with a cut-off by the steam

Hubbard

496 valves, is it or not advantageous not to wire-draw the steam as it passes through the steam-pipe, previous to its passage from the steam-chest into the cylinder.

A. It is.

Q. Is there a loss in the use of the throttle valve?

A. There is, just to the extent to which the pressure is reduced; there is a great loss in working steam by wire-drawing.

Q. In taking note of the operation of Youngs and Cut-
497 ter's engine, did you apply any practical test to it, to see whether or not the sudden or quick movement of the valve, in admitting steam into the cylinder, had any practical effect.

A. The effect was, that it admitted it, so that there was no indication whatever of wire-drawing.

Q. How did you ascertain that?

A. By an Indicator.

(Mr. *Keller* objected to the introduction of any testimony
498 as to the Indicator, on the ground that its indications were uncertain, and depended upon a great variety of circumstances at the time of the working of the engine.

Mr. *Seward* said that the defendants would show that their machine accomplished the purpose of preventing wire-drawing; and, in order to do so, the witness should be allowed to answer as to the manner in which he tested it.

The court decided that the defendants were entitled to show that their principle was not a mere theory.)

499 Q. Did you apply a test to the operation of the defendants' engine to satisfy you, as a mechanical engineer, that there was a practical result from the quick opening and closing of the valve?

A. I did; the Indicator indicated that there was no wire-drawing whatever at the commencement of the stroke, and, so far as we could see, and the diagram was reliable, the closing of the valve was instantaneous.

Q. I would ask you not merely as to opening but also as to closing?

A. So far as we could judge from the diagram, I think
500 the effect of the opening and closing of the valve was as near perfection as we could expect.

Q. Will you be good enough, sir, to point out what properties, if any, you find in the valve-gear, in Mr. Corliss' arrangement, which are adapted to a connection of the governor with the cut-off valve?

A. It is this: that, by a peculiar construction of the valve-gear, and the peculiar mechanical action of the parts by which the detachment is effected, the thing of which the regulator controls the position, that is, the brass stop in the

model, does not have to move by the regulator and by the operation of detachment, that is, the governor has nothing to do at the instant of detachment, or while that is taking place, but to stand still and do nothing; it would, perhaps, for an instant, be held quiescent by the pressure of the hook-rod against the brass stop, and of that against the incline, and thus, probably, a momentary resistance would be offered to the action of the governor. 501

Q. How often does the adjustment of the governor take place in the operation of the engine?

A. Twice in every revolution—at each end of the stroke. 502

Q. Will you be good enough to state the effect of the operation of Mr. Sickels' valve, described in his patent, in regard to the opening of the valve port?

A. The puppet-valve arranged in this manner, or with the gear which is used in a puppet-valve, cannot open, from the nature of its construction, so rapidly as a slide-valve moving past the port, which is put in motion before it arrives at the port; for the reason that it has to be started from a state of rest, and of course must be started slowly, and that slow movement necessarily opens the port slowly, 503
which is rendered of still more consequence from the fact that the edges of the valve, which constitute the joint with the seat, make but a small angle, as they are generally constructed, with the line, that is to say, the bevel makes not a very great angle, in the line of its motion, with the piston-rod; those difficulties are not met with in a slide valve, as it is put in motion and is moving rapidly before the port commences to open, and, from the nature of its construction, it does not have to rise from its seat, but has simply to move to different positions upon its seat. 504

On being *cross-examined* by *Charles M. Keller, Esq.*, one of the counsel for the plaintiffs, the witness, *William C. Hibbard*, testified as follows:

Q. I want to get, accurately, some statements which you made yesterday; did I understand you to say that the kind of valve-gear in use at the time of the grant of Sickels' patent consisted of the lifter-rods, moving parallel with the valve-stem, and taking hold of the valve-stem by means of 505
the lifter, and operated by toes on a rock-shaft, deriving motion from the eccentric?

A. Yes; that is, so far as I have any personal knowledge, the only way in which they have been worked.

Q. Was that the kind of valve-gear, sir, in general use at the time of this invention?

A. It was, for moving puppet-valves, that is, in this vicinity; at the West there was a gear a little different from that, as I have been informed, but I never saw it.

Abbott

506 Q. Was not the puppet-valve, at the same time, the kind of valve most generally used in this country?

A. Not so, broadly stated; the slide-valve is more generally used; for steamboats, I think, the puppet-valve is used more generally than any other, but in stationary engines the sliding-valve.

Q. Is the kind of valve-gear which you have described as used with puppet-valves, applicable to slide-valves?

A. No, not generally.

Q. What, then, did you mean, yesterday, by saying that
507 the kind of valve-gear referred to in Sickels' patent, was that most generally in use at the time of his invention.

A. I meant that most generally in use in connection with puppet-valves—the valves which he describes in his patent—and, so far as he describes any gear, he describes that kind.

Q. Do you not know, as an engineer, that at the time of this invention there was a considerable controversy existing between American engineers and English engineers, as to the relative merits of puppet-valves and slide-valves, the Americans advocating the puppet-valve in preference to
508 the slide-valve, and the English advocating the slide-valve in preference to the puppet-valve?

A. I am not aware that there was any particular controversy; the practice is that English engineers generally use slide valves, even for marine engines, and American engineers use puppet-valves; that is the practice, but I am not aware that there has been any controversy in the case.

Q. I will ask you whether it was not a question of relative merit, due to this circumstance, that the slide-valve, by reason of its connections, is in motion after and before the steam-port is opened, and that, in consequence of that,
509 power is consumed in moving the valve during the time that the port is closed, whilst the puppet-valve does not consume any portion of the power of the engine until the port begins to open?

A. If I understand the question, those were considerations which determined the preference of it; the question whether it was to be used or not, according to the opinion of engineers, was whether the greater friction of the slide-valve made a sufficient objection to counteract the advantage of it; I do not know that the question is settled to this
510 day.

Q. Was Mr. Corliss the first to make a slide-valve, in which the valve would be in motion before the opening of the port?

A. No, sir.

(Mr. *Seward* objected to the form of the question, and the court ruled that it was not proper to ask whether Mr. Corliss was the first to make a slide-valve.)

Q. Did I understand you to testify, in your examination in chief, that sliding and rotating valves were also known at the time of Sickels' invention? 511

A. I do not know of my own knowledge; I cannot now recall any example of rotating valves, such as are here now, being used; I have been informed so, but I do not know.

Q. Did you or did you not swear that they were known at the time of this invention of Mr. Sickels'.

A. I do not recollect.

Q. Sliding and rotating valves?

A. Sliding valves were known, and I believe rotating 512
valves were known at that time.

Q. That is all I want to know; I do not want a speech upon thesubject, but I want you to answer my questions. In all the various kinds of valve-gear, did not the mechanism which opened the valve also govern its closing?

A. What valves?

Q. In all these various kinds of valve-gear, used both for the puppet-valve and the slide-valve, whether straight or rotating, then in general use, did not the valve-gear which opened the valve also control its closing? 513

A. That was the general practice.

(*Mr. Blatchford* objected to the question as irrelevant. Objection overruled.)

Q. In all the varieties of valve-gear then in use, was there not a rod employed to form the connection between the eccentric, the cam, or the rock-shaft, which imparts the motion, and the valve-stem, to impart the required motion to the valve?

A. There was a rod in connection.

Mr. Keller.—Cannot you answer my question yes or no.

The Court.—Let him explain. 514

Mr. Keller.—Let him answer and then explain.

A. It cannot be answered yes or no; because the premises composing the question do not exist; in some valve-gear there is not a rock-shaft at all; there is always a rod connecting the eccentric with the valve.

Q. You have not understood my question, or else you would not commence to answer in that way; I want to know whether, in the varieties of valve-gear then in general use, at the time of Sickels' patent, there was not a rod 515
employed to form a connection between the eccentric, the cam or the rock-shaft, or any other part of the mechanism that gives the motion, and the valve-stem, to impart the required motion to the valve?

A. I can only answer that as I did before, that some valves had valve-stems and some not; some sliding-valves were driven directly from the rocker, without the inter-

Hubbard F

516 vention of a valve-stem, but there was always a rod connected with the valve.

Q. Did not that form a connection in some way with the valve?

A. Certainly; a connection between the eccentric and the valve.

Q. In view of the office performed by this rod, in all these modes, are they not all mechanical equivalents for the lifter and lifter-rod used in connection with the puppet valves?

517 A. I do not consider that they are.

Q. Taking the steam-engine as a machine, is not the substitution of one known kind of valve for another kind the substitution of an equivalent?

A. It depends upon whether it is an equivalent or not. Its being known or unknown has nothing to do with the fact whether it is an equivalent or not.

Q. What is the purpose of a valve in a steam-engine? Is it not to admit and shut off the steam?

A. Yes.

518 Q. Well sir, taking the combination then of the steam-engine, which consists of the cylinder and piston, the steam pipes leading to the boiler, and the exhaust pipes, and the valves for alternately opening and closing the ports, taking those as the mechanical combination, is the substitution of one kind of valve for another, to effect the closing and opening of the ports, the substitution of an equivalent?

A. With that limitation they might be considered as equivalent.

Q. In what connection would they not be equivalent?

519 A. When you are taking into consideration the action of the valve by itself, as compared with another valve, then they are not equivalents of themselves, though they may be considered as equivalents when you take the engine as a whole. When you are considering the character of the valves by themselves, then they are not equivalents.

Q. Well, sir, on the assumption that the first invention of the steam-engine consists of a cylinder and piston, with valves for alternately opening and closing the ports, to ad-
520 mit and shut off the steam, and to let off the steam after it has done its work, working full stroke, would the alteration of that, by the introduction of cut-off valves to work the steam expansively, entirely destroy the original combination, or would it constitute an improvement upon the original combination?

A. I should think it would constitute an improvement, because it would perform all the functions it performed before, and something in addition, performing the old functions in the same way as before.

Q. In a given combination of machinery, can you substitute one known equivalent, of different form, for any one of the elements of that combination, without making a corresponding change in the form of the other parts of that combination? 521

A. I cannot answer the question, it is so general; sometimes it might be necessary and sometimes not; it depends altogether upon the character of the combination; you can only judge of such cases by an examination of the thing itself.

Q. I would rather generalize; I want to test your particular reasons by general principles. 522

The Court.—Can you suggest any principle to which you wish to draw his attention?

Q. Can you, in the combination of the steam-engine, substitute sliding valves for puppet-valves, without making a corresponding change in all the valve-gear?

A. You cannot.

Q. Would such a change destroy the original combination constituting the steam-engine? 523

A. Not as you state it, because the combination consists of several aggregations of mechanism, such as the valve-gear, piston-gear, and so on; modifying one would not change the general character; it would only change the character of that part.

Q. Does it not change the general form of the engine?

A. To a certain extent; it depends upon a great many other things in connection with it, so that I cannot give a definite answer to the question.

Q. Do you know of any better arrangemnet for regulating the closing of puppet-valves than the one described in 524
Sickels' patent?

A. In my private opinion, I think there is a better; it is better to close them with positive motion.

Q. When you testified that Sickels' mechanism could be set to cut off steam at nearly any portion of the entire stroke, and the defendants' only within range of the half-stroke, did you mean to testify that, for that reason, they were entirely of a different combination, for the purpose of tripping the valves?

A. Not entirely different, but there is a substantial dif- 525
ference between them nevertheless; there is a similarity between them to a certain extent; the one embraces properties beyond the other, which I consider substantial.

Q. I should like to have something more definite than that. Will it constitute a different combination, or substantially the same combination?

A. It would be different, because there is more of one than the other.

526 Q. Suppose you close up the open space between the two wedges in Sickels' adjustable piece, so that it cannot be reversed and act upon the wedges: can it then cut off beyond half-stroke?

A. Please repeat that question.

Q. That open space between the two wedges is what permits the points of the spring to pass through, in rising, without disengaging the valve, so that when that is reversed the trip will take place in descending Now, sir, I want to
527 know whether, by closing up the whole of the space between those inclined planes, so that the adjustable piece cannot be reversed, the result will be that the engine will only cut off within the range of the half-stroke. Can it then cut off beyond half-stroke?

A. No; but on the other hand, if it were set at the proper position, when the lifter came back it would break it; that would be the result of it.

Q. Would it require ingenuity, in cases of that sort, to
528 prolong these inclined planes, to prevent such action?

A. Not any remarkable ingenuity.

Q. I suppose you could do it without claiming the right to a patent; I want to know whether, in view of that change, it would constitute Sickels' a different combination?

A. I think it would substantially modify it.

Q. Do give us a distinct answer; I do not want any special pleading; I am examining you as an engineer, and not as a lawyer. Would that change constitute it a substantially different combination?

529 A. With that explanation, I think it would; because the property which is prominently put forth upon the patent, as I learn from the patent itself, is that it possesses the property of cutting off beyond half-stroke, and it is different in so far as it is deprived of that property.

Q. In what part of the patent do you find that property named?

A. I cannot now recollect it, but that is the idea which, in reading the patent, was conveyed to my mind; I think I could find the language if I had the patent.

530 Q. Do you find it in that part of the patent from which you read yesterday, when you spoke of the "immediate appendages" to the combination?

A. If I understand the question, no.

Mr. Keller.—(Reading from the patent.)—"But were the "sliding piece I, with wedges or inclined planes, reversed, "the spring would then not be opened by the ascent, but "would be opened by the descent of the stem."

A. That is part of it; the first allusion to it is this:—(reading from the specification)—"By means of the apparatus which I have devised, the spring F may be opened,

“ and the stem B, with its valves, may be tripped at any 531
“ time during the ascent or descent of the lifter, and the
“ steam may consequently be cut off at any part of the
“ stroke of the piston.”

Q. Now, sir, is that idea there, or that arrangement for cutting off steam beyond half-stroke, something besides the combination which enables it to cut off at any range within the half-stroke?

A. No; I do not think it is; I think it is a property of the combination which permits it to perform both offices. 532

Q. I want to know whether that is necessary to the working of the engine for cutting off within half stroke; or whether it is something which enables it to cut off beyond the half stroke, and an addition to the property which permits it to cut off within half stroke?

A. I do not consider it a mere addition, but an inherent property in that combination itself, in the elements employed to make up the combination.

Q. So, if you used an engine simply for cutting off within half stroke you would not infringe Sickels' patent. Is that your understanding? 533

A. No.

Q. What do you mean then?

The Court.—I understand the witness to say that the plaintiffs' engine can cut off at half stroke, or at any intermediate point less or more than half stroke?

The Witness.—Yes.

Mr. Keller.—But I want to know, whether using that apparatus, so that it will only cut off during the half stroke, would constitute it a different combination? 534

A. My answer is, that, if so modified, it is deprived of that property of cutting off beyond half stroke; it is a substantial modification in view of the whole invention, as set forth in the patent, as I understand it.

The Court.—Your idea is that this patent of Sickels intrinsically requires that the engine should have the function of cutting off beyond half stroke?

A. Yes.

Mr. Keller.—And, deprived of that, its substantial identity is destroyed? 535

A. It is not entirely a different thing, but you have deprived it of a part of the invention.

The Court.—I understand from the witness now, that although Sickels' engine may perform the functions of cut off above and below half stroke, yet if that power be removed, and it is limited to cut off within half stroke, there would be then a substantial difference.

536 *Mr. Keller.*—That is what I understand him to say.

Q. Now, sir, do you find the reversing property of that adjustable stop I enumerated, among the elements of the combination in the specification of claim?

A. Not in those terms; it is a "stop I."

Q. Do you find any allusion in the claim to that property of reversing the adjustable piece?

A. Neither to that nor to any other property, but simply an enumeration of the parts to co-operate.

537 Q. In enumerating the members of Sickels' combination for tripping or disengaging the valve, you name the flexible or spring latches, capable of passing between the wedges, when the adjustable sliding-piece is reversed; is that double flexibility an essential element of Sickels' combination?

A. Not an element, but it is a property in one of the elements, which is essential to perform the functions described.

Q. Would the substitution of a spring or weighted lever, having a spring action only in one direction, destroy the
538 substantial identity of that combination?

A. I do not understand the question.

Q. It seems to be my misfortune not to be able to make myself understood by you. I will put the question again. Would the substitution of a spring or weighted lever for the double spring catches described in the patent, destroy the substantial identity of the combination described in the patent?

A. I cannot answer that question; the description does not convey any specific mechanical structure to my mind,
539 that I should be able to judge of it.

Q. Does it not convey *that* structure, (pointing to the black model of Sickels' apparatus) to your mind?

A. It does not; the patent describes that structure; I have not got your idea.

Q. The question is this: Would the substitution of a spring lever or weighted lever, for the double spring catches in this model, destroy the substantial identity of the combination described in the patent?

A. I think it would modify it substantially, but not destroy it; in the remaining parts there would be a similarity
540 of action, but the difference I consider to be substantial.

Q. The difference is substantial?

A. I think so.

Q. Would it destroy the substantial identity of the combination?

A. As an identity, yes.

Q. If I understood your last answer, the arrangement represented in this large machine (from the De Laine mill) would not be substantially the same combination as you find in Sickels' patent?

A. I think not. 541

Q. Now, sir, in Sickels' combination, are the wedges or inclined planes upon the adjustable slide indispensable to the substantial identity of his combination?

A. I think so, in connection with the other elements. Without them, the other parts would be inoperative.

Q. Now, sir, if, instead of the wedges on the adjustable piece and the spring, you should substitute a latch operated by anything other than an inclined plane, but performing the same functions—that of latching and unlatching the valve-stem—would that constitute it an entirely different 542 combination?

A. I cannot answer you without seeing it.

Q. Cannot you imagine such a thing. Here (handing witness a skeleton model) is a model, which does not work very well. Suppose *this* rod here to represent the valve-stem, and *this* piece here to represent the lifter, and *that* the lifter rod. Now, sir, there is a lever-catch turning on *that* fulcrum pin on the end of the lifter, and having a weight on the end, as a substitute for a spring, and this latch taking into a notch in the valve-stem, and having an 543 arm at the side, striking upon the adjustable stop attached to a standard; so that, when the lifter descends, the catch, by the preponderance of this weight, falls into a notch in the valve-stem, and, on the rising of the lifter, the lever end of this catch is brought into contact with a stop, liberates the valve-stem, and permits it to descend, while the lifter comes down and reëngages again. I want to know whether the substitution of that lever catch, acting against the adjustable stop, instead of the adjustable piece with its wedges and the spring catches, would constitute a substantial difference? 544

A. I think it would, for the purposes of detaching.

Q. Would it detach the parts as well?

A. As well as what?

Q. As well as the spring catches described in the patent?

A. It would, in the ascending movement, perhaps fully as well, but, in the descending movement it would not do it at all.

Q. It would not cut off beyond half stroke?

A. Yes. 545

Q. Within the half stroke, however, this arrangement would be just as adjustable as Sickels', would it not?

A. Yes, as far as I can see, supposing the stop was made to be adjusted up and down, and placed in the position required.

Q. In testifying as to Sickels' combination, you enumerated as the "immediate appendages" the standard and the

546 securing screw for the adjustable piece. Do you consider these essential to the substantial identity of the combination described in the patent?

A. I consider that something must be there in substance, in order to enable it to operate, and for that reason is indispensable.

Q. Now, sir, would not a substitution of any other device in mechanics that would hold that adjustable piece in its proper position when set, be an equivalent for the standard and the set screw?

A. I think it would.

547 Q. In enumerating the essential elements of Sickels' combination in reference to the tripping apparatus, did you take into consideration the concluding words of that part of the specification, which are: "substantially in the manner set forth."

A. Yes, sir.

Q. Now, sir, does that language, addressed to you as a
mechanician, give you any latitude for substituting, in the
combination described, known mechanical equivalents?
Looking at that language, the concluding sentence—"sub-
stantially in the manner set forth—"addressed to you as a
548 mechanician, do you consider it as including, for the mem-
bers of the combination specified, known mechanical equi-
valents?

A. Certainly, if they were equivalents; but it is extremely difficult to have equivalents in a simple combination.

Q. Now, is not this weighted latch an equivalent for a spring latch?

A. No, it is not an equivalent.

549 Q. It is not?

A. No.

Q. Why not?

A. Because it has not the property which the spring latch has, to enable it to cut off beyond half-stroke.

Q. I limit it to half-stroke, now.

A. That does not alter its properties, in my mind.

Q. For the purposes of this investigation, we will set aside
the cut off beyond half-stroke, and limit it to cutting off
550 within half-stroke; Corliss' only cuts off within half-stroke,
does it?

A. Not beyond that.

Q. Would the substitution of a weighted lever for that spring lever, constitute that apparatus a substantially different combination?

A. I think it would, in view of its being a simple mechanical operation; I think it would be substantially; it would be a near approximation to it.

Q. Is not *that* a combination of a spring latch with some other combinations, constituting a machine? 551

A. Not in the way you state; it is a combination of which a spring latch is part.

Q. Does it not perform, in its combination with a lifter and the stem of the valve—does not this lever and latch perform all the functions performed by that spring-lever in *that* one?

A. So far as regards the engine, yes.

Q. So far as regards the combination of the lifter with the valve-stem, does it not perform every office that is performed by the spring-lever? 552

A. Yes, it detaches.

Q. Do you not know that when that combination is presented to you there, with a spring-lever, that you can substitute a weighted lever latch for that spring-lever, without the exercise of invention?

A. I do not know that.

Q. Would it require the exercise of invention to do that?

A. It would, provided it was the first lever latch ever made; it may be well-known. 553

Q. Do you not know that a weighted lever latch is a well-known device for engaging and disengaging?

A. Yes; and for that reason it would not require invention, for it would be presumed to be known by every man in the trade.

Q. Assuming that a party was the first inventor of a lifter, combined with the stem of the valve by means of a latch, and that in his patent he described a spring latch, operated by wedges, would the substitution of a weighted lever latch be a substantially different combination? 554

A. No; because the combination claimed ——

Q. I am not asking you as to the claim, but as to the operation; I am not addressing you as a lawyer, but as an engineer.

A. I understand it to be this: that the claim which is supposed would be for a combination of the valve-stem with the lifter, so as to be detached; in that case both mechanical parts perform that office, and, therefore, in that view are equivalent. 555

Q. Now, sir, in Sickels' patent, so far as regards cutting off within half-stroke, do you find any other combination, in the mechanical description of it, than the combination of a lifter with a valve-stem, by means of a catch, to alternately connect and disconnect the valve-stem from the lifter?

A. I find that that is the result; and I find certain combinations of mechanism described for the purpose of producing that result; that is my understanding of it.

Q. Taking Sickels' description of a mechanical combina-

556 tion, irrespective of the claim—(I am aware that you have put a construction upon this claim, heretofore, and I want to avoid that; I am addressing you as an expert and not as a lawyer)—taking the mechanical combination described in the patent, or represented in that model, (of Sickels' apparatus,) which needs no legal construction, do you find there any more than a combination of a lifter with a valve-stem, by means of a catch which can alternately take hold of and liberate the valve-stem?

A. I do find such combination.

557 Q. Taking that as a mechanical combination presented to your mind for the first time, I want to know whether the substitution of a lever catch would constitute this an entirely different combination?

A. Not entirely.

Q. Would its substantial identity be destroyed?

A. I think it would, as a special combination for producing a common result—common to both of them.

Q. What difference would there be in it?

A. Difference in the mechanical elements employed to effect that purpose.

558 Q. Would it require the exercise of invention to substitute the one for the other?

A. Not if they were both well-known.

Q. Have you not already said that the spring latch was well-known?

A. It was well-known, whether I said so or not.

Q. Assuming that it was not well-known before, and that you, for the first time, contrived this weighted lever catch, and that you substituted that for the spring catch in this mechanical combination of the lifter with the valve-stem,
559 would you, by the contrivance of this weighted lever catch, destroy the substantial identity of the combination found in the model of Sickels'?

A. I think you would, as a mechanical combination.

Q. Then, sir, the first time that a rotating or slide-valve was substituted for a puppet-valve, in the steam-engine, that destroyed the substantial identity of the combination of the steam engine?

A. No.

560 Q. Why not?

A. Because the substantial combination which makes up the machine called the steam-engine, embraces a great many other parts besides that one.

Q. Does the valve in the steam-engine have exactly as important a relation to the piston and cylinder, as this catch to the connection between the valve-stem and the lifter? Is it not a mechanism for engaging and disengaging?

A. Yes.

Q. Is not the steam-engine made up of mechanical de- 561
vices, combined together?

A. It is.

Q. Where, then, do you draw the distinction between the one and the other?

A. The distinction is this: that a steam-engine is a combination of combinations, each simple combination being devoted to perform some simple functions. These functions again combine to perform some higher functions, and those functions again combine to form an engine. When
we are dealing with a simple elementary combination, it 562
stands in a different relation to the engine from what it does in taking the highest combination which gives the machine its general character.

Q. Where do you draw the line where the substitution of an equivalent destroys the identity of a combination, and where it still maintains that identity?

A. I have not so stated.

Q. Have you not stated, that, in a steam-engine, the sub-
stitution of a different kind of valve would maintain the 563
same combination?

A. As an engine, yes.

Q. Have you not stated that, in this (skeleton model), the substitution of a weighted latch for a spring latch would destroy the combination?

A. As a simple combination, the element for performing a simple function. That simple function can only be used to perform some higher purpose in the machine, and those functions combined with some higher functions again, con-
stitute a steam-engine. This combination which we are 564
considering (referring to the black model of the plaintiffs' apparatus) consists of the valve-stem, the spring on the lifter and the adjustable sliding-piece. Each of these elements are simple pieces of matter, and can have no mechanical functions whatever. They all together perform the function of detaching. That function of detaching, in connection with the valve-stem, we will suppose performs the function of admitting the steam; and these several mechanical func-
tions combined again form the steam-engine. In consider- 565
ing the subject mechanically, we have to keep these distinctions in mind, in order to have a clear idea of each of them.

Q. I understood you to testify, that the combination found in the defendants' mechanism, for tripping the valve, is entirely different from that found in Sickels' patent?

A. In what machine?

Q. In the defendants'.

A. I so consider it.

566 Q. And that it has not one of the elements of Sickels' combination?

A. I think so.

Q. Do you not find steam-valves in it?

A. Yes.

Q. Are not all steam-valves equivalents for each other in the steam-engine?

A. I cannot tell, unless I know how they are used.

Q. Well, sir, are not rotating valves equivalents for puppet-valves?

A. As regards the combination which makes the steam-
567 engine, they are, if used for the purpose of working the steam-engine.

Q. That is what they are used for in the steam-engine?

A. Sometimes, and sometimes for other purposes.

Q. Is not a valve-stem the instrument which is connected with the valve inside of the valve-chest, and which passes through a stuffing-box, and extends out of the valve-chest, to form a connection with the mechanism which is to operate the valve?

A. It is, where a stem is used.

568 Q. Can a valve within a steam-chest be operated without forming a connection with the outside of the chest?

A. It cannot, practically.

Q. Now, then, is not the term "stem" applied to that piece of mechanism—that part which forms the connection between the valve inside of the valve-chest and the mechanism outside?

A. It is, if it is a stem. If it is something else which transmits the motion within the steam-chest, it is something else. A stem, mechanically, is drawn in the direction of its
569 own length.

Q. Is that your definition?

A. As far as I know, that is the general term applied to it. In a few instances, the word stem has been applied to a rotating spindle, as it is called.

Q. You stated yesterday, that the valve-stem, in Sickels' arrangement, passes through a stuffing-box?

A. It does.

Q. And what I call the stem, but you call the rocking-
570 shaft, in defendants' model—I want to know whether that does not also pass through a stuffing-box?

A. It does.

Q. Now, sir, is it not by means of this rod, which you call a rocker, and which I call a stem, that the connection is formed between the valve inside of the chest and the mechanism outside?

A. It is.

Q. And is it not so in all forms of valves?

A. It is, so far as I know; that is, all forms of valves 571
which are operated from the outside.

Q. Now, sir, in this throttle-valve, is not *this* the stem of the valve (pointing to a model)?

A. It is properly the spindle. Some people call it a stem; but the proper technical term is "spindle."

Q. It is the instrument which forms the connection between the valve inside and the mechanism outside?

A. Yes.

Q. And in every case of the valve, no matter what form 572
the valve may have, is it not necessary that there should be a valve-stem, or some other rod, by whatever name you choose to call it, passing out from the valve to the mechanism outside?

A. Yes, if it is to be operated outside?

Q. Do you know of any instance where it is to be operated inside?

A. Certainly, there are a variety of valves which are operated without any action from the outside.

Q. I mean steam-valves? 573

A. Yes.

Q. Now, sir, in the defendants' arrangement is there not an arm attached to what you call the shaft of the valve, by which the valve is moved to open the steam-port to admit steam?

A. There is.

Q. Is not that arm connected with a rod receiving motion ultimately from the eccentric?

A. It is.

Q. Is not that rod alternately connected with the arm, 574
to move the valve, to open the port for the admission of steam, and alternately disconnected from it, that the valve may be moved independently and more rapidly in the opposite direction, to close the port and cut off steam, whilst the rod continues its motion, and comes back again to be reconnected to repeat the operation?

A. I believe, yes, if I remember the question, for it is pretty long.

Q. It is long, but my object is to get the evidence in 575
such a shape that it can, when on paper, be read and understood. (Question repeated.)

A. Yes. The only thing I have to modify is, that the motion with which the valve gets back has nothing to do with the rod; it comes back by a separate agency, which may be more or less rapid—generally more.

Q. Do you mean to qualify your answer to that question? I want you to say whether the conditions of my question are to be found in the defendants' engine or not?

A. It is, with my exception. The question implies that

576 the movement back of the valve is immediately connected with the opening movement of it by the rod.

Q. Not at all?

A. I so understood it.

Q. It has no condition at all. (Question repeated.)

A. It is so. The only explanation is, as I said, that whether it moves more rapidly or not, the rod has nothing to do with it.

Q. I am speaking about the fact. Is it not so in fact?

A. Generally, I believe it is.

Q. Is it not so always in fact, when that mechanism is
577 in operation?

A. Not always.

Q. In what condition does it appear that it is not so?

A. When the weight is so regulated as not to fall rapidly, by shutting up the screw.

Q. When the engine is at work, performing its business, is there any instance in which the valve does not close faster than the rod returns to its position?

A. I never took special pains to ascertain that, but I think that in the dash-pot of one of Youngs & Cutter's engines it did not close so rapidly as to hook it?

Q. Would it cut off steam?

578 A. Yes, because it opened rapidly and closed rapidly.

Q. Do you not disconnect that arm from that rod while the engine is cutting off?

A. No, sir.

Q. Then, sir, if the valve does not close faster than the return motion of this rod, will it cut off steam?

A. Yes.

Q. Will you explain how?

A. Because it is detached while the rod is still going that way, and it is closing at the same time that the rod is
579 moving in the opposite direction.

Q. If the valve be drawn back again by the rod, and never disconnected, but comes back with the motion of the rod, and the engine does not cut off, but works at full stroke, tell me how it can cut off if the valve returns slower than the rod which moves it?

A. For the simple reason that it is closing while the rod is going in a direction which would open it—it has less distance to move.

580 Q. My question was, whether the rod was not disconnected from the arm of the valve-shaft, so as to permit the valve to be moved in the opposite direction, to close its port, while the rod continues to make its motion and return again to re-take hold of the arm?

A. It does so.

Q. When that valve is liberated from that rod, do you 581
know of any instance, when the engine was working and cutting off steam, in which the valve did not close its port before the rod returned to its original position to re-take hold of the arm?

A. No, sir, I never knew of any such instance. It could not do it, because the time the rod returns to take hold of the rocker arm, is nearly at the termination of the stroke. It must detach in order to cut off.

Q. Does not precisely that operation take place in Sickels' arrangement? 582

A. It does. That is, it must detach, in order to cut off.

Q. Is there not a rod which is moved by the mechanism of the engine from the eccentric ultimately, which is alternately connected with the valve-stem, for the purpose of opening the valve, and which is alternately disconnected from the valve-stem, that the valve may close its port—move in the opposite direction and close its port—while the rod continues to perform its motion and come back to retake hold of the valve-stem?

A. If I understand the question, there is. 583

Q. Is not this connection and disconnection of the parts produced by means of a catch or latch, forced into place by a spring?

Mr. Blatchford.—Which machine are you talking of?

Mr. Keller.—I mean in both.

A. In general terms, yes.

Q. In specific terms, how then?

A. They both may come under the denomination of a latch—both the mechanisms employed.

Q. And is not this connection broken at the required
time, by bringing the catch or latch out of its connection 584
in which it is held by the spring?

A. Yes.

Q. Is the spring a material part of this combination?

A. Of which combination?

Q. The combination which I have named here in both these engines, for the purpose of holding this latch in place, that it may be disconnected?

A. I am not aware that any combinations have been
mentioned. 585

Q. Can the lifter-rod perform all these operations upon the valve-stem, alternately catch it, be connected with it, and alternately liberated from it, without mechanical combination?

A. It cannot.

Q. And you have stated that a spring is used to keep the catch in connection in both machines?

A. Yes.

586 Q. Is the use of that spring a material part of the combination, either in the plaintiffs' or in the defendants' arrangements?

A. It is, as I understand it.

Q. Now, sir, suppose that were turned upside down, (laying Corliss' model on its side,) suppose that arrangement be inverted, so that this connecting rod would hook on to the arm in *that* way, would it need a spring then to make it engage?

A. I should think not.

587 Q. Would substituting the weight in that position to form the engagement and permit the disengagement, destroy the substantial identity of the arrangement in the defendants' engine?

A. I think it would modify it to that extent.

Q. Will it operate precisely in the same way as having a spring?

A. Not precisely in the same way.

Q. What difference would there be?

A. It would derive its power from gravity instead of a
588 spring.

Q. Would it not perform all the functions of engaging and disengaging as well?

A. It would perform them, but I do not know if as well or not.

Q. Have you any doubt about it?

A. I think it would do it as well.

Q. Do you think that the spring is a material part of the combination?

589 A. Not in that case. It is not there. The conditions are changed.

Q. If I change Mr. Sickels' so as to make it catch or latch by means of gravity instead of a spring, does it then change its substantial identity as a combination?

A. I think it would. I cannot tell until you show me some specific mechanism.

Q. Have I not shown you one?

A. I think that was substantially different.

Q. Is it not because it happens to be the plaintiffs' instead
590 of the defendants'?

A. I do not know that that has anything to do with the subject.

Q. In one case, the substitution of the gravity for a spring would not change the substantial identity of the combination, but in the other it would?

A. I did not say "change." I said it would "modify" it, if I am not mistaken.

Q. If a weight or other body is to be lifted or moved, as a question of mechanics, can it not be moved as readily by means of a lever, as by means of a wedge?

Equivalent

A. I presume it can, as a general proposition? 591

Q. Now, as a general proposition in mechanics, whenever an instrument is used, in a given mechanical combination, to lift a body or move a body from one place to another, is it not well known, and is it not a matter of instruction to young mechanics, that that can be done either with a lever or with a wedge?

A. I do not know that I can answer; I have not got any definite idea from the question.

Q. If a weight or other thing is to be lifted or moved out
of the way, as a means of doing this, is not a lever an equi- 592
valent for a wedge?

A. It is, or may be, that is, if it is made so—if it so acts upon the weight as to be its equivalent. Whether it is equivalent or not depends upon how it is used—what functions it performs.

Q. I am now speaking of the fact of lifting merely, of lifting a body. Do you not know, as a mechanician, that when a body, in a given mechanical combination, is to be lifted to a certain extent, that you can do that either by
means of a wedge or by means of a lever? 593

A. Certainly it can be done by either.

Q. And that the extent of its motion to which it has been carried, if it be done by a lever, will result in delineating the form of a wedge, which, under the same circumstances, would have moved it?

A. The position from which it is moved to that to which it is moved describes an angle; the two lines would make a wedge.

Q. In other words, does not a lever action always gener-
ate the form of a wedge? As, for instance, if I have this 594
knife to lift, and I do it by means of a lever, and lift it up to that extent—if I draw a vertical line from the body which has been lifted to its original position on the base line, will not those two lines, with the final position of the lever, delineate a wedge?

A. Yes; four of them.

Q. Which would, if used instead of the lever, have elevated the body to that self same height?

A. Yes. 595

Q. Is not that an axiom taught in mechanics?

A. Not exactly, that I know of.

Q. Is it not a rule among mechanicians that the one can be used indiscriminately for the other?

A. Not, as I understand; one can be used for the other in some cases, but not in others.

Q. But where it can be used, does it require the exercise of invention to substitute it?

596 A. It depends upon the organization of the machine, and the office it performs in it.

Q. Well, now, sir, in this—if *this* catch is to be disengaged, and *this* rests upon *that* as a fulcrum, do you not know as a mechanician, that without the exercise of invention you can either disconnect *that* by putting a wedge-formed projection on *this*, and moving *that* in a straight line, or by making *this* all straight and elevating *that* end? (illustrating.)

A. You can do it by putting the wedges ——.

597 Q. I want a direct answer. Can you not do it in either one of those two ways?

A. You can do it without the exercise of invention, because it is a well-known mode of using them.

Q. Then the substitution of a lever as a means of mechanically disengaging the catch would not be an invention?

A. That depends upon whether one performs the office better than another. It cannot be stated in general terms.

Q. Now, sir, as a means of disengaging that catch, to
598 liberate this valve, and without any ulterior object but for that purpose alone, I want to know whether the motion of that wrist-plate, moving up this end, will effect it any better than to move that in a straight line, and have the wedge in here?

A. I think it would be better practically, because it does not need the wedge.

Q. As a means of making simply that disconnection, which is the cheapest—to continue to move that in straight lines as it has always been done heretofore, or to take away the
599 old mode, and to substitute that plate?

A. It would be difficult to tell. It would depend altogether upon the structure of the engine. The cheapest way would be the best?

Q. Now, taking the engine as it exists, with this rod moving in a straight line, and you want to disconnect it for the purpose of cutting off steam, instead of taking in steam at full stroke—to effect that, would you not have to disconnect this rod at a different part of the stroke?

A. Yes.

600 Q. I want to know whether it would not be easier and cheaper for you simply to add a small wedge to the top of that rod to effect the disconnection, than it would be to throw away the old valve-gear and substitute this wrist-plate?

A. If it required all that substitution, it would be.

Q. Simply as a means of forming the disconnection, would not the alteration of putting on a wedge *here* be just as effectual as this wrist-plate?

A. I do not think it would be so delicate.

Q. Why not? 601

A. Because I think it would require a greater longitudinal motion of the rod to effect the disconnection, unless the incline were made so steep as to be prejudicial in its action against the stop. Having such valve-gear as is here exhibited, that is the simplest way to do it.

Q. I am speaking now with regard to the cutting off of the steam. I am not speaking of this wrist-plate as a means of modifying the motion of the valves in connection with that wrist-plate. In both cases, do you not have to overcome the friction due to the force necessary to perform this 602
disengagement as the rod slides under there?

A. Yes.

The Court then adjourned to January 2d, 1855, at 11 o'clock, A.M.

January 2d, 1855. 11 o'clock, A. M.

The *cross-examination* of *William C. Hibbard*, a witness for the defendants, was resumed.

Q. I perceive in your testimony that you call *these* rods, 603
in the defendants' apparatus, hook rods?

A. Yes.

Q. Now, is not *this* the hook-rod, as generally known in the steam-engine,—this one that comes from the eccentric?

A. Sometimes.

Q. Is there not, in the engine used by the defendants, as in all other engines, a hook on this rod and a handle, so that the valve-gear can be disconnected, at any time, by the hand of the engineer?

A. Sometimes; it is on the defendants'. 604

Q. The purpose of that is to be able to disengage and start the engine by hand?

A. Yes.

Q. One of the distinctions which you drew between the Sickels' combination for tripping and the defendants' is, that in Sickels' arrangement it can be set to cut off beyond half stroke, and the defendants' cannot; I will ask you, whether it is a disadvantage or an advantage to be able to set the cut-off of an engine beyond half stroke? 605

A. For the cut-off to be used for the purpose to which Sickels applied it, I should think it was an advantage; sometimes an occasion would arise where it would be an object to cut off beyond half stroke.

Q. Why do you confine that to Sickels'?

A. Because the valve-gear to which that improvement was applied, was the common steamboat valve-gear, and it sometimes might be necessary, in that case, to cut off beyond half stroke.

606 Q. Why might it not be just as advantageous in any other engine, to cut off beyond half stroke?

A. Because in stationary engines we have better convenience for keeping the power more constant, and there is a more constant requirement on the engine than there is in marine engines.

Q. Do you understand Sickels' invention to be limited to steamboat engines?

A. I understand it to be limited to the devices he has specified.

607 Q. Do you consider his invention of that device as limited in its use to steamboat engines?

A. It can be applied to any engine.

Q. Now, sir, in a rolling-mill engine, does not the resistance which the engine has to overcome vary more than it does in the steamboat engine?

A. It does, as a general thing, I should think.

Q. Then, will you tell us why it is, that to have a capacity to cut off beyond half stroke in a steamboat engine, in which the resistance does not vary so much, will be an ad-
608 vantage, and that it will be a disadvantage in a stationary engine for a rolling-mill?

A. It grows out of the nature of the employment; in the rolling-mill we know, as a general thing, what the maximum power required would be, and an engine, to be adapted to it, should be so large that it should never require to cut off beyond half stroke, to meet those conditions, and then the fluctuations of power would be within that; in a steamboat it would be better to cut off within half stroke, but
609 there may circumstances arise (for instance, in going into a head-sea, where the facility for making steam might be reduced, and there is liability to get into a position of danger) where, to give an extra amount of power, it would be of advantage.

Q. Now, in the defendants' engine, if you were to get into such an emergency as that, could you not make it work full stroke?

A. You could.

Q. Just as well as Sickels'?

610 A. Yes, you could make it work at full stroke just as well as Sickels'.

Q. And you think that in the defendants' it would be a disadvantage to be able to adjust anywhere between half and full stroke?

A. Not particularly a disadvantage; but a difficulty would arise from the construction of the valve-gear.

Q. You think that an engine cannot be made, having the governor connected with it, to govern the cut-off between half and full stroke?

A. No; I do not say that; I do not know what could be made; but I know it would not be convenient to adapt it to this. 611

Q. If you could apply the governor to Sickels' arrangement, would it be an advantage or disadvantage to enable the governor to set the cut-off at any point beyond half stroke, as well as within half stroke?

A. I do not know how the governor could be applied.

Q. I am supposing that we can?

A. Then tell me how it is to be done; describe the machinery. 612

Q. I will not describe the machinery at present; assuming that the governor can be connected with Sickels' arrangement, would it be an advantage or disadvantage to have the governor regulate that cut-off beyond, as well as within half stroke?

A. I think it would be an advantage, if it could do it well—not of much practical use, however, because a cut-off at that point is not desirable to be used for general purposes.

Q. If I understood your examination in chief correctly the 613
other day, you stated that the mode of unlatching, as represented in the defendants' model, was more sensitive than the mode described in Sickels' patent, will you explain why?

A. I do not know that I stated it in those terms; but what I meant was, that a slight modification of the mechanism of the regulator effects a change in cutting off more sensitively when combined with mechanism of *this* description; the reason is, that a very small rising or falling of the slide will effect a considerable difference in the point of 614
time at which it shall be cut off, owing to the peculiar motion of the parts, by means of the detachment.

Q. Those are not the means I mean; does it not require more power to disengage *that* catch from *this* arm, in the valve-lifter of the defendants', than it does to disengage the catch from the valve-stem in Sickels' arrangement?

A. It takes less in Corliss'.

Q. Why so?

A. Because the pressure in proportion to the opening of the valve is not so great on *that* point as it is in Sickels'. 615

Q. Is not the pressure on that catch due to the weight?

A. Yes.

Q. Now, sir, is that weight that is used for closing the valve in the defendants' greater than the weight which hangs on the catches in Sickels'?

A. I should think it was.

Q. Assuming the weight to be the same in both, will not the amount of friction to be overcome in liberating the catches, in both cases be determined by the amount of weight resting on the catches?

616 A. No, not entirely. The distance which the catch has to move to effect a detachment must be taken into account.

Q. Is there any necessity that one catch should have a greater movement than the other?

A. Yes; I think from the way in which the valves are constructed that you would require larger surfaces in Sickels' than you would in Corliss'.

Q. Is it necessary that these catches should do any more than hold up the valve-stem, in this black model of Sickels'?

A. So far as any one operation goes it is not necessary.
617 They want to be in such a form that they will wear well.

Q. Please explain to the jury why it is that it must impinge more in one than in the other—both having the same amount of weight—to hold the catches?

A. I do not understand the question?

Q. Explain to the jury why it is that one must take greater hold than the other, when the amount to be held and lifted is the same in both?

A. The difference is due to the fact that in Corliss' the
618 hook-rod, when seizing, bears upon a catch with a rounded edge, and it requires but little lateral movement to detatch it. In Sickels' it requires a deeper notch, or the liability is that the corners will wear round both on the lifter and the valve-stem, and by sliding out fail to effect a permanent attachment.

Q. Do you not know that there is just as much fear of the corners of *these* two catches wearing round, as there is of the catch in *that* to wear?

A. No, sir.

619 Q. For what reason?

A. For the reason of the peculiar form of its edge. (Witness explained on the models.)

Q. Cannot the catch in Sickels' be bevelled off in the same way, so as to hold on at the bottom of the notch?

A. It might be.

Q. Would it require invention to make that change?

A. Not very much.

Q. Would it require any?

A. I do not think it could be considered as requiring any
620 invention.

Q. Now, sir, would it destroy the substantial identity of the arrangement for cutting-off steam—not as a means of regulating the motion of the engine to the load, but simply as a means of cutting off the steam—would it destroy the substantial identity of the defendants' arrangement, to break the connection between this wedge-rod and the governor, and adjust this slide by hand?

A. I think it would.

Q. Why, sir?

A. Because it would then lose the property which is due to the combination of the machine. 621

Q. Would it not be an adjustable cut-off?

A. Yes, but not such an adjustable cut-off as that is.

Q. I am now leaving out of the question altogether, the means of regulating by the governor. As a means of cutting off steam and adjusting the point of cut-off, would it not be substantially the same as it is now?

A. I do not think it would be, for the reason I told you. The governor cannot regulate the velocity of the engine, 622 except by means of combining it with something which —

Q. I ask you to suppose the governor to be disconnected from it. Having the governor disconnected, and this rod adjusted by the engineer, would it destroy the substantial identity of the apparatus for tripping the valve and cutting off the steam?

A. For tripping the valve it would not; for cutting off it would.

Q. Would it not cut off the steam?

A. It would cut off the steam, but not in the manner it 623 does now.

Q. Would it not cut it off precisely the same as it does now?

A. No. The steam would be cut off; but, as a cut-off, it would not have that property which it has now, in combination with the regulator—that is, the property of controling the velocity of the engine.

Q. Suppose the slide of the governor be secured, so that the balls will not be affected by any change in the velocity of the engine, would not the engine then cut off at a fixed 624 point?

A. It would.

Q. If you shift that, and fasten it at another place, would it not cut-off at a different point?

A. It would.

Q. Would it do precisely what is done on Sickels', when the sliding-piece is shifted and set?

A. It would, so far as the cutting off of steam is concerned.

Q. Would it not regulate the cut-off just exactly as it 625 does in Sickels'?

A. It would not regulate it at all.

Q. Would it be cutting off at the same place after you shifted it?

A. No.

Q. Would it not then regulate; if you want to cut off short in the plaintiffs' you shift *this* (the sliding-piece); and in the defendants' you shift the slide of the governor's balls, so as to cut off shorter; would not that regulate the point of cut-off in both cases?

Hubbard

626 A. It would change it.

Q. Would it not regulate it?

A. No.

Q. You have an engine that is working with a certain amount of steam, and with a certain amount of load, and all that is reduced so that you want your engine to cut off shorter, to adapt the power to the demands of the resistance; in Sickels' arrangement, as an engineer, you would shift the stop, and make it cut off shorter, to adapt it to the
627 condition of the load,—would you not?

A. As a constant condition, I should.

Q. In the arrangement of the defendants, you would shift the slide of the governor to make the engine cut off shorter?

A. I should let it take care of itself.

Q. I am assuming that you shift it by hand, and fix it there; have you not regulated the cut-off to suit the new condition?

A. If you merely consider the condition of the load and
628 the steam, changing and regulating it, you have.

The Court.—It would cut off at that point?

A. Yes, until a farther change was made.

Mr. Keller.—Now, then, sir, was not the addition of the throttle-valve to the steam-pipe of the steam-engine, in combination with the steam-valves that admit the steam to the cylinder, an improvement on the steam-engine at the time of its first introduction?

629 A. Certainly, it was an improvement; I do not consider that, however, the combination in which it was placed; the introduction of the throttle-valve was, undoubtedly, an improvement.

Q. Was it not added as a means of regulating the admission of steam that should reach the steam-valves?

A. Yes.

Q. Then was it not used in combination with the steam-valves?

A. Not directly, but rather in combination with the general structure of the engine.

630 Q. If, as you have stated, the throttle-valve was for the purpose of regulating the amount of steam to be admitted to the valves, was it not used in combination with the steam-valves?

A. I do not consider it so; it was in combination with the engine.

Q. Was it not directly in combination with the steam-valves?

A. No more than with the exhaust valves; the steam would pass through both.

Q. Does not the throttle-valve admit steam first to the steam-valves, and, after the steam has performed its functions in the cylinder, it passes out of the exhaust valves? 631

A. Yes.

Q. Is there any direct connection between the throttle-valve and the exhaust-valves, in that view?

A. None, except through the steam-valves.

Q. Then is it not proper to say that the throttle-valve was combined with the steam-valves?

A. I do not think it is, as a technical combination, which
I understand to be inquired of. 632

Q. When the throttle-valve was first used, was it not controlled by hand?

A. I think not; my impression is that it was not, but I cannot recollect.

Q. As an engineer, I ask you now whether the throttle-valve in steam-engines was not controlled and operated by the hand of the engineer, before the governor was combined with it?

A. No, sir, I believe not; that is my impression, but I
am not certain. 633

Q. On the assumption that the throttle-valve was introduced and operated by hand, before the governor was applied to it, was not the throttle-valve, in that condition, working without the governor, a means of regulating the speed of the engine? A. It was.

Q. Did the addition of the governor to that, which rendered it self-directing by the speed of the engine, alter the substantial identity of the combination of the throttle-valve with the engine? On the assumption that the throttle-valve
was first introduced in the steam engine, and worked by 634
hand, did the addition of the governor to the throttle-valve, to render it an automatic adjustment, destroy the substantial identity of the combination of the throttle-valve with the engine?

A. It did; I think so.

Q. Did it take away anything that existed in the engine before?

A. No, I do not think it took away anything; it changed its properties in a measure.

Q. That is, it rendered that automatically adjustable, 635
which before was adjustable by hand?

A. Yes.

Q. Now I will ask, in your judgment, do you consider that as an improvement added, or a substantial change of the original combination?

A. It was an improvement added. Whether it could be considered a substantial change, is a pretty close question. But there is a substantial change induced by the combina-

636 tion, and it would be treated rather as an improvement and
addition.

Q. In view of that, would the addition of the governor
to the adjustable slide of Sickels' cut-off, to render that automatic
in its arrangement, instead of an adjustment by
hand,—would that be an improvement added to, or a substantial
change of the original combination?

A. I think it would change the combination, because it
would change essentially one of the parts, which must be
637 changed in order to be able to combine the governor with
what is left of it.

Q. Was there not as great a change required at the time
the governor was added to the throttle-valve?

A. I think not. There is this distinction, which, in my
mind, is entitled to great weight. By combining the governor
with the cut-off, instead of combining the governor with
throttle-valve, it is not merely adding the function of the
throttle-valve to the cut-off, but it is making the cut-off
638 do what it never did before, and so operating as to dispense
with what was necessary before to regulate it.

Q. Suppose you take this model of Sickels' arrangement
of this sliding adjustable piece, and you add to it a sliding
plate, like the sliding-rod in the defendants', with inclined
grooves in it embracing the stem, having the same inclination
that the wedges of the sliding-rod of the defendants'
engine have, and you connect that slide with the governor,
will it not then regulate the cut-off by the governor, as effectually
639 as it does in the defendants'.

A. I think it would, if the sliding-plate were properly
guided. I do not think it would be as sensitive as the defendants'.

Q. Why not as sensitive?

A. Because the springs in Sickels' are much longer in
contact with the inclined planes, than the hook-rod in the
defendants' is in contact with the stem and, while thus in
contact, would be likely to hold the regulator still. It does
not leave the regulator as free as Corliss' does. Another
640 reason why it would not be so practically good as the defendants'
is, that the cut-off cannot be regulated so short,
which might be necessary in case the engine was running
empty. Because, by Sickels' arrangement the steam must
always be admitted during the whole time the detachment
is being effected, for, the moment the valve-stem begins to
move it lets in steam—it must rise sufficiently to detach,
and, when rising, will admit steam; but, in Corliss' arrangement,
you can so regulate as to cut off steam entirely.

Q. Do you ever want to cut off when you do not admit
steam at all?

A. Yes, sometimes—to detach it so that it cannot admit
steam.

Q. Is not the readiest mode to do that, to remove the stop altogether? 641

A. In the working of an engine, supposing the main belt broke, it is important that it should have power to arrest the steam instantly, and it is probably of consideration in that arrangement.

Q. If you place that stop so that the spring catches in Sickels' are entirely disconnected from the stem, will not the engine work without admitting steam?

A. It would not work at all. 642

Q. I put it to you as an engineer, after a thorough examination of that model of the plaintiffs', whether, with the modifications I have described, or rather the addition of the slide in connection with the governor with Sickels', it will not be capable of cutting off at any portion of the stroke which can be effected by the defendants'?

A. I think there would be a practical difficulty for a small portion of the space at the commencement; but after that I think it will.

Q. Do you think there is any portion of the half-stroke 643
within which the defendants' can cut off that Sickels' apparatus will not, with that addition?

A. Practically, I think, at the first part of the stroke it will not do it, from the difficulties which I mentioned.

Q. Would the alteration, with the addition of that slide connected with the governor, destroy the substantial identity of Sickels' combination; or would it be an addition to that combination?

A. I think it would destroy the identity. I think that
the properties of the sliding-piece are changed. It is no 644
longer a sliding-piece as described, nor has it the same properties.

Q. Does it perform the function of disengaging the valve-stem, wherever it happens to be placed by the governor?

A. No, sir; its property consists in operating those springs, and that is all it does.

Q. Does it possess the property of disengaging the valve, and permitting it to close at any point where the governor
happens to hold it? 645

A. That property is due to the combination. It is the combination of the slide, springs and valve-stem together, which produces that result.

Q. Please to answer my question. When that is in connection with the governor, at any portion of the operation of the machine, wherever the governor happens to hold that adjustable piece, will it not disengage the catches and permit the valve to close?

A. Yes.

Hubbard X

646 Q. Does it not possess precisely that property, if secured there, at that time, or at any period of time?

A. Yes.

Q. Then, sir, does not the governor simply add to this adjustable piece, the property of being set and regulated in its position by the governor, instead of by the set-screw in the hand of the engineer?

A. It makes that change.

Q. Then you call that a change which entirely destroys the substantial identity of Sickels' apparatus as a cut-off?

647 A. I do not say "entirely destroys it;" I say it substantially changes it.

Q. I want your judgment whether it substantially destroys the original combination, or whether it is an addition to that combination.

A. I think it destroys the combination; a mere addition does not reach it, in my opinion.

Q. Do you know, sir, if Mr. Corliss was the first to combine the governor with cut-off valves, instead of the throttle-valve?

648 (The defendants' counsel objected to any inquiry into the originality of Corliss' inventions.

The Court decided the question to be admissible, for the purpose of putting before the jury the particular elements constituting the combination in Corliss' engine, but not for the purpose of establishing that Corliss' patents were not for an original discovery, or of in any way disproving the validity of Corliss' patents. To this decision the defendant's counsel excepted.)

Q. Prior to the invention of Corliss, do you know if the
649 governor was connected with cut-off valves?

A. There is an account in the books; but I do not know, of my own knowledge, of any practical arrangement for doing that thing. The thing has been considered desirable by engineers to be accomplished, and attempts have been made to do it.

Q. Do you not know from the books that the governor has been combined with the cut-off valves of the steam engine?

A. From accounts in the books I know that it has been
650 attempted.

Q. And in all cases, to your knowledge, is not the governor so connected as to shift the apparatus which determines the period at which the valve shall close?

A. Yes.

Q. Did I understand you to testify, the other day, that the wrist-plate of the defendants', which communicates motion to the valve, was invented with special reference to making a sensitive cut-off?

A. I do not know that I stated it was in the mind of the

nventor. I stated that the arrangement of valve-gear, in 651
connection with the wrist-plate, of which it is a part, made it particularly applicable to be worked in that way; but I cannot tell whether it was in the mind of the inventor.

Q. Do you not know that that wrist-plate was invented to operate the slide-valves before Mr. Corliss applied it to cutting off?

A. That I cannot tell. I have no means of knowing whatever.

Q. Now, sir, with reference to the wire-drawing of
steam. Will not steam pass through a small aperture with- 652
out wire-drawing, if that aperture is in proportion to the size of the chamber which is to be filled with steam?

A. Wire-drawing is due to the fact that the steam flows through an aperture, whether large or small, where the pressure on one side of it is greater than upon the other.

Q. Now, sir, at the time the piston is first started, does it not move a great deal slower than it does towards the middle of the stroke?

A. It does. 653

Q. Is it not due to the fact that at this point (illustrating on the defendants' model) just as the crank is passing the dead centre, when the connecting rod is in line with the axis of the connecting rock-shaft, the piston is not moved, and it starts with a slow motion, and that motion accelerates until the cranks gets at right angles, and then diminishes until it gets to the opposite dead centre?

A. Yes.

Q. Now, sir, if you take a quarter motion of the crank in
its circle, supposing the position from *there* to *there*, does 654
not the piston have to pass through a much longer space than in the other quarter of the revolution coming round to *this* point by reason of the curvature of the motion?

A. Yes.

Q. Now, sir, in all steam engines, does not the valve open a little before the piston begins to move?

A. Some do, and some do not.

Q. Is it not a general practice to give a lead to the steam-valve?

A. It is by some engineers, and by some it is not.

Q. But it is practised? 655

A. Yes, by some.

Q. Now, sir, is not a puppet-valve engine usually worked so as to open the valves a little before the piston begins to move?

A. It depends upon the opinion of the engineer who uses it.

Q. Would it constitute an essential difference in the engine whether you give the valve a lead, or do not give it a lead?

656 A. No.

Q. If the valve has a lead, and the steam-port is opened a little before the piston begins to move, is there any danger of wire-drawing the steam, in view of the fact that the piston at the commencement of its stroke is moving very slowly, as compared with its ultimate motion at the middle of the stroke?

A. Judging from diagrams that I have seen, I should think there was. In avoiding this difficulty you are apt to create another—the "cushioning" of steam, which detracts
657 from the power of the engine.

Q. Are not all these questions requiring an exercise of the judgment of the engineer in considering which of these various forms he will adopt—either to give the lead or not, to make the valve lap or not, and to use the check-ring in the puppet-valve or not—do they not all look simply to the question of admitting the steam at the time of starting the engine?

A. They all look to admitting the steam properly, so as
658 to work the piston properly.

Q. Is it not a matter of election among engineers which of these various modes they will select?

A. Certainly.

Q. Does the motion of this wrist-plate have anything to do with the closing of the valve?

A. Not of the steam-valves, when they cut off. I will modify that a little to this extent—that when they cut off very short, the valve has less distance to move, and the weight less distance to fall to close it. It would modify it a little.

659 Q. Would that be a material alteration?

A. I do not think that would be material.

Q. So far as regards merely imparting motion to the valves, does not the wrist-plate take the place of the rocking shaft in other engines?

A. I do not know that it takes the place, because it is a member of an organization in the engine—it is a rocker.

Q. Is it not interposed between the valves and the eccentric, as a rock-shaft is interposed between the valves
660 and the eccentric?

A. It is in that position.

Q. Does not each one of the wrists on this wrist-plate operate as a rock-shaft?

A. It operates as a rocker.

Q. Now, sir, I understand you to state that one of the advantages of this wrist-plate is, that it reduces the amount of motion of the valve during the time that the steam-port is closed. When the puppet-valve is used, is not the valve at rest during the whole of the time that the port is closed?

A. It is.

Q. Now, sir, as a question of power, which requires the 661
most power—the arrangement which keeps the valve slightly in motion during the time the ports are closed, or the arrangement which keeps the valve perfectly still?

A. To that extent, the one which keeps the valve in motion—to that extent alone.

Q. But I understood you to state, that the advantage here was, that, as the valve is set in motion before it opens the port, by the time it reaches the edge of the port, and begins to open it, it is then in a more rapid motion than if it started
at the moment of opening the port? 662

A. It is.

Q. I will ask you if that precise result is not produced in the puppet-valve, when used with a check-ring?

A. It is, when the check-ring will fit tight; but that is the difficulty in using it. If the check-ring be made steam-tight, it will be liable to catch or stick, and if it be not make steam-tight, it will wire-draw.

Q. Would there be any more friction or any more liability of the valve to be checked and stopped by reason of
the friction of that ring than by reason of the friction of the 663
surfaces of rotating valves on their seats?

A. Yes.

Q. Why, sir?

A. Because, in the defendants' engine the slide-valves are merely pressed by the steam against their seats, and, if there be any obstruction upon the seat, the valve is free, in rotating, to ride over it, by overcoming the pressure of the steam; but, with the check-ring, even the expansion of metal would make it stick, or a contraction of the metal make
it go loose, and any little dirt would be likely to stick it up. 664

Q. Is not the valve-seat exposed to the same heat as the valve itself, and therefore as liable to expansion or contraction?

A. Not at first.

Q. Have you ever known any difficulty of that sort to arise in the use of the check-ring in steam-valves?

A. I am not familiar with their use. I have heard them described, but never saw them used.

Q. As a general proposition, what kind of valves require
the most power to move them—puppet or slide valves? 665

A. Long slide valves, or rather what are called the English D valves, are the most difficult to move.

Q. I will ask you whether the puppet-valve, as a general rule, does not work with less power than any of the slide-valves that are known?

A. Yes. As a general proposition it is true; that is, provided the puppet-valves are balanced.

Q. Does not the puppet-valve, for a given amount of

666 motion, present a greater area of opening than the slide-valve or the rotating valve?

A. No; there is no difference that I know of.

Q. It does not?

A. No. It depends upon the perimeter of the valve as compared with the breadth of the port.

Q. Now, sir, assuming the area of that steam-port (producing a model) to be equal to the area of the steam-port in this model of Sickels', does not Sickels', in the lifting of the valve, open the area all around that circle?

A. It does.

667 Q. Does not this (small model) open on one side of the area?

A. It does.

Q. Then, sir, if you here open both sides of that by a given amount of motion, would it not present a larger area than if you opened only one side of it?

A. Yes.

Q. As Sickels' opens the area all around, and this (small model) only on one side, does not the puppet-valve present
668 a greater area for a given motion than the slide-valve?

A. No. You can make that slot just as long as the perimeter of the valve.

Q. Would that not make a larger area of opening?

A. That depends upon the width again.

Q. Is it your judgment that that which only opens upon one side will present as large an area of opening as that which opens all around?

A. I did not say so.

Q. If this valve were precisely the size of that steam-
669 port, when let down to cover it entirely—I will ask you which valve presents the greatest area of opening, to lift the valve up from the port an eighth of an inch or to slide it over the area an eighth of an inch?

A. To lift it up.

Q. Is not that precisely the problem presented by the puppet-valve and slide-valve?

A. It does not seem so to me, as the question has been propounded.

Q. Now, sir, I will call your attention to the dash-pot
670 for a while. I will ask you, whether, if you take the dash-pot exactly as described in Sickels' patent, and place it under the weight in the defendants' engine, the means for regulating the closing of the valves, in both apparatus, would be substantially alike or substantially different?

A. I think the means of arresting the weight would be the same.

Q. That is not my question. Would the means then

employed for regulating the closing of the valve be substantially alike or substantially different from Sickels'? 671

A. I should say, taking them all together, they would be different. The means employed in regulating the weight would be alike.

Q. Would the apparatus for regulating the closing of the valve, in its construction, arrangement and combination, be substantially alike or substantially different from Sickels' patent.

A. I think substantially different; but, as I said before, so far as arresting the motion of the weight by means of that 672
dash-pot, they would be alike.

Q. Would it make a substantial difference in the combination of this apparatus for cutting off steam, to place the spindle of the puppet-valve horizontal instead of vertical?

A. I think it would be inoperative.

Q. Are puppet-valves always used with the stem in a vertical position? Have you not known them used at an angle of 45 degrees?

A. Not as steam-valves.

Q. Had you ever been on board the steamer Missouri 673
before it was destroyed by fire?

A. No.

Q. You do not know how puppet-valves were used on board that frigate?

A. I do not. I heard it alluded to in the direct examination, that they were set at right angles with the line of the cylinder.

Q. In your judgment, would that valve fail to operate if it were placed in that position?

A. I do not know that; I do not think it would operate in 674
a horizontal position.

Q. For what reason?

A. Because the valve would ride upon its side altogether, with its whole weight, and you would have to use some extraneous weight to close it.

Q. Now, on the assumption that it would work in that position, would it not require a weight to be added to it, to close it?

A. Yes, some extraneous force.

Q. Then, having to close that valve by means of a weight, 675
would you not do it by connecting the stem with a rock-shaft, having an arm with a weight suspended to it?

A. That would be one way.

Q. Then, sir, if that weight within the dash-pot should strike upon the plate of the engine, as you can imagine this small weight here to fall, from a height of four, five or six inches, upon this solid iron plate, would it not injure the valve, and make it slam upon its seat?

676 A. If the weight struck that, it would not hurt the valve, because it would not let the valve shut.

Q. Would it not injure the valve, even assuming that it did not shut?

A. I do not see how it could.

Q. Would not the jar be felt through every particle of matter composing the connections?

A. It would depend upon the character of the connections.

Q. Assuming the connections to be as they are here, in
677 the defendants' apparatus?

A. It might be felt to a small extent by the valve, but not much. As I understand your question, it would probably transmit a very small amount of jar.

Q. As a practical engineer, do you believe that the valve would resist those shocks for one week?

A. As I understand your proposition—that the weight strikes upon the bed, I think it would, so far as that is concerned; but I do not think the whole arrangement would be good for anything.

678 Q. I am speaking only of the jar upon the valve—merely the shock transmitted to the valve through the particles of matter constituting the connection—would the jar occur if the weight were to fall on water?

A. It would fall without injury, if it fell on water and did not strike its seat.

Q. If you apply the dash-pot to that, in that connection, would not then the dash-pot regulate the closing of that valve, as the weight descends, and prevent the slamming of the valve?

679 A. It would, to the extent that it would check it at the last part of its motion.

Q. Would it not, in that connection, regulate the closing of the valve, and prevent the slam of the valve as effectually as it does in this direct connection? I suppose the dash-pot to be substituted for the solid plate on which the weight is to fall.

A. I assume the same premises; but, if the weight impinges upon the solid bed, and the valve does not come to
680 its seat, it will not slam; the weight will receive the shock, and not the valve.

Q. I suppose that plate of metal to be taken away, and the dash-pot as described in Sickels' patent to be substituted, so that the valve can come to its seat. I want to know whether the dash-pot, in that connection, would not as effectually regulate the closing of the valve, and prevent its slamming, as in the case of a direct connection as represented in the black model?

A. I think it would prevent the slamming and regulate the closing, provided the connection was rigid. 681

Q. What are the proportions of the engine used by the defendants, Youngs & Cutter? About what is the size of the cylinder?

A. Apparently about 12 inches in diameter.

Q. What stroke?

A. Forty-two inches.

Q. Do you remember about what range of pressure they work steam?

A. We examined it, and I think it was from 40 to 70 pounds; it is a small boiler, and fluctuates a good deal. 682

Q. About what number of horse-power does it work?

A. That depends a great deal upon the maker; I do not know how they would rate it; engines of three feet stroke we rate at 30 horse-power; that at Youngs & Cutter's would, I suppose, work 35; an engine working without a throttle-valve rates considerably higher than those made with a throttle-valve.

Q. In the arrangement I suggested sometime ago, of a puppet-valve on a horizontal stem, worked by a weight in connection with a dash-pot below the weight, would that arrangement be substantially different, as a mechanical combination, from that described in Sickels' patent? 683

A. I think it would be covered by the invention as described in the patent; I wish to add, in connection with that, the supposition that, by the pressure of the weight, the valve finally comes to its seat, and is not arrested by anything else.

Q. The question pre-supposes the plate to be removed, and the dash-pot to be substituted? 684

A. In the first part of the proposition it does not.

Q. Now, sir, I understand you to state that the placing of Sickels' dash-pot under this weight, to check its descent, and prevent the weight from slamming on the plate, when employed in connection with the defendants' arrangement, would not be substantially the same as Sickels'?

A. I think not.

Q. Would it not effectually regulate the closing of the valves in the defendants'?

A. I think it would substantially as well. 685

Q. Would it not effectually prevent that weight from slamming on the frame or plate of the engine?

A. It would bring it down gradually.

Q. Would it not perform all these offices as effectually as the defendants' air dash-pot?

A. So far as the closing of the weight is concerned, I think it would.

686 Q. So far as preventing a jar upon any part of the machine?

A. Yes.

Q. Now, sir, I understood you to state that the adjustable cup was necessary to the proper working of Sickels' dash-pot, in connection with the puppet-valve?

A. I think so.

Q. Have you never seen the water dash-pot used in connection with the puppet-valve, without the adjustable cup?

687 A. I think I have.

Q. Did it not work as well as with the adjustable cup?

A. I do not know but that it would, making the adjustment some other way; but you must have a means of adjusting it.

Q. Where would you put the adjustment, if you did not have an adjustable cup?

A. You can adjust it on the valve-stem if you choose, and that is done sometimes, I believe; or in some other connection of the valve-stem with the plunger that works
688 in it.

Q. Is there any necessity for varying this adjustment, when shifting the cut-off, in any portion of the stroke?

A. If the position is altered to any extent, I think there would be, but that is to make it work noiselessly.

Q. If you cut off at three-quarters stroke, will the valve fall from a greater height than if you cut off at a quarter stroke?

A. Yes; it is considerably higher than at the quarter.

689 Q. How much higher?

A. The difference in movement—twice the time of closing the valve, if you can estimate it; that is, from the time it drops until it gets to its seat.

Q. Now, sir, when you cut off at three-quarters stroke, does not the lifter of the valve come back again to a position about the same as the position which it reaches in rising at a quarter of the stroke?

A. The lifter so hooks the rod by it as to trip before that,
690 in order to enable the valve to go down; you have to take the time of falling into account, also.

Q. I want to know this; we want to cut off at a quarter stroke of the piston, at one time; at the next time we want to cut off at three-quarters of the stroke; and I want to know whether there is any material difference in the height from which the valve will have to be tripped and fall, in cutting off at each of these two positions—any material difference?

A. I cannot tell; there would be just the difference I have mentioned.

Q. Would not that be an exceedingly small difference? 691
A. Yes.
Q. Would it have to fall as high as if cutting off at one-third stroke?
A. About that I should think—one-third from the latter end would be a little further than one-fourth from the first end.
Q. It would not be three times as much?
A. No, but I think it would approximate to twice as high.
Q. Is not the greatest height from which the valve is to fall, when it is cutting off at half-stroke? 692
A. Yes.
Q. Then, if the dash-pot is so adjusted that it will properly check and prevent the slamming of the valve when varying through the range of the half-stroke, will it not be properly adjusted for a cut-off at any range beyond the half-stroke?
A. I do not understand.
Q. You state that the greatest height that the valve has to fall is when cutting off at half-stroke?
A. Yes. 693
Q. Now, then, if the dash-pot is so adjusted as to properly check the valve when cutting off at any range within the half-stroke, will it not answer the purpose of checking the valve when cutting off beyond half-stroke?
A. I think it would, if it were fully under this condition.
Q. Would it not answer for cutting off at half-stroke?
A. Yes.
Q. In working the arrangement of Sickels with puppet-valves, have you ever known an adjustment either of the cup or of the plunger for any variation in the cut-off? 694
A. I have never known it, or known of the cut-off being changed. The nearest that I have seen was on an engine which worked upon an arrangement something like that (full sized working parts of De Laine engine). I found when the engine was cutting off short that it made the valves pound very much.
Q. That cut-off was not adjusted when you were there? 695
A. It was continually shifting, because it was combined with a regulator.
Q. The dash-pot combined with a regulator?
A. No, the valve-gear.
Q. If it slammed when it cut off very short, then did you not infer that it was not properly adjusted?
A. Yes.
Q. What is the extent of height to which the puppet-valve is lifted in Sickels' arrangement?

696 A. I do not know any particular limit. The usual rate is one-third of its diameter.

Q. What was the greatest height of the engine you speak of as slamming?

A. When I saw it, it did not raise over half an inch. It was cutting off short.

Q. In the engine to which this belongs (full sized part of De Laine engine) what was about the height at which the plunger fell—its ultimate height?

A. About three inches.

Q. Now, sir, in the defendants' engine, does not the
697 weight fall from as great a height as the valve in Sickels'?

A. There does not seem to be any definite height for that in Sickels' arrangement; because that arrangement does not extend so far.

Q. Taking the defendants' engine, which appears to be a small one, I will ask you from what height the weight falls when cutting off at the greatest length?

A. About two inches.

Q. Do you not know that it is beyond three inches?

698 A. I know it is not beyond three inches; I would say it was not up to $2\frac{1}{4}$ inches.

Q. Did you ever measure it?

A. I looked at it with my eye.

Q. What was the height the weight fell when cutting off at the long portion of its stroke?

A. Not over two inches.

Q. Did you see that engine working up to the limit of the cut-off?

A. I saw it rise and fall without cutting off, and that
699 would carry it to the maximum movement.

Q. When you are cutting off short, the weight does not fall from so great a height as when you are cutting off long?

A. No.

Q. Now, is there not about the same variation in that as in the descent of the valve in Sickels'?

A. Yes.

Q. Now, then, if it is necessary to adjust either the cup or the plunger to the cup in Sickels' arrangement, to pre-
700 vent the valve from slamming when cutting off long—when shifting from a long to a short cut off—is there not precisely the same necessity for adjusting the connections of that weight in the defendants', when it is made to shift from a short to a long cut-off?

A. No; because there is nothing for it to bring up against. It comes against no fixed object like the seat of the valve. There is no slam to it; and whether it goes a little farther, or not quite so far, is a matter of no conse-

quence, provided it leaves the rocker where the hook will 701
catch it.

Q. On the defendants' engine is there not a screw connection like this for adjustment?

A. All the connections or rod-heads are made in the same way.

Q. You have the means here of adjustment, if you choose?

A. Yes.

Q. Now, sir, when you put the engine together, if you
find the weight is not in a proper position with reference 702
to the arm or the valve, cannot they shift this so as to fix that position properly?

A. Yes, adjust it to the hook.

Q. It is an adjustment like this?

A. Yes.

Q. Is not that adjustment equivalent to the adjustment of the cup in the dash-pot?

A. Yes, if I understand your question as an adjustment of the weight.

Q. Have you any doubt as to understanding it? 703

A. No.

Q. Did I understand you to say the other day, that Sickels' dash-pot, as described in the patent, if properly proportioned, would not work with air?

A. I do not think it would, that is, in connection with puppet-valves.

Q. Have you ever seen it tried?

A. I never have.

Q. Now, I will turn your attention to the dash-pot, as
separated from the valve. In Sickels' arrangement, I under- 704
stood you to state that the plunger is free to descend until it goes down to the secondary cup or reservoir?

A. It is so described.

Q. And water flowing all around the plunger until it gets to the contraction?

A. Yes.

Q. Now I will ask you whether, in the defendants' the plunger does not descend freely until it gets by the hole in the side of the cylinder, through which the air escapes with
comparative freedom? 705

A. You can regulate the descent by a screw.

Q. Will it not descend as freely as the plunger in Sickels'?

A. Not quite, because it sometimes is adjusted to retard the descent a little; the pressure of the air inside, escaping from the hole, retards it a little; it does not fall like a weight in free air.

Q. Does it not, in Sickels', have to remove water from under it?

706 A. I do not know but that one would be the same as the other.

Q. Is it not in both the object to permit the falling body to descend freely until towards the end of the downward motion?

A. Comparatively so.

Q. Is there any object in having it to fall less freely in one than in the other?

A. I think there is a little, which is due to the difference
707 in the closing of the two kinds of valves; the one can go past its port and close rapidly, and the other cannot.

Q. Until it comes to the checking part, is not the object the same in both, to descend freely?

A. The check part, in the defendants', does not come until after the port is closed.

Q. I am speaking before the checking takes place in each of them, I am not speaking about the valves at all?

A. Comparatively.

Q. In both, is not the descent checked by closing an aper-
708 ture through which the fluid passes?

A. Yes, substantially.

Q. And is not the checking in both due to the fact that towards the end of the downward motion the plunger gradually closes up an aperture through which the fluid before passed freely?

A. It is due to the fact that it closes it; its *gradual* closing has not much to do with it; when air is employed it has nothing to do with it.

709 Q. You cannot close the aperture suddenly, can you?

A. No, but practically in no time.

Q. Cannot this be altered readily to work in water as well as in air—this arrangement of the defendants?

A. Yes, I suppose it can; if you put it in a bucket of water it would work, but it would require to change the diameter of the orifice considerably.

Q. By making the aperture large, in proportion to the density of the two fluids, would it not work?

A. I believe it would, though the effect would be to ar-
710 rest the weight with water, rather more suddenly than with air, because there would be no elasticity practically with water.

Q. In substance it would work the same, would it not?

A. I think it would.

Q. Now in this apparatus of the defendants, is there not a valve in the bottom of the cylinder?

A. There is.

Q. Is it not the object of that valve to let in air freely, while the plunger rises and before it passes the side aperture which was closed by the descent of the weight?

A. It is. 711

Q. In Sickels' patent, do you not find a valve in the plunger for the same purpose?

A. For a similar purpose.

Q. Is not the substitution of one for the other equivalent?

A. No, I do not think, taken as a combination, that the purpose of one is equivalent to the purpose of the other.

Q. Is is not well known among pump-makers that where you want a valve to move in a cylinder, you can either put the valve in the plunger or in the cylinder itself? 712

A. I do not know; I am not a pump-maker.

Q. Do you not know, as a mechanician, that where the object is to allow an entrance of fluid into a cylinder, between the bottom of the cylinder and the bottom of the piston or plunger, that you may put a relief valve in the cylinder or plunger?

A. Yes.

Q. Does it require invention to pass from one to the other?

A. I should not think it would. 713

Q. I understood you to state that in the defendants' engine, at the time the valve was first checked, the plunger was within about half an inch of its downward motion?

A. Half an inch of the top of the hole; it was about an inch or an inch and a quarter from the lowest limit of its motion.

Q. After it has been checked?

A. No; after the valve is closed, the weight passes from an inch to an inch and a quarter.

Q. But, until it passes the hole, the descent is not materially checked? 714

A. No; I should think not much.

Q. I would ask you, as a practical engineer, whether the fall of two weights of that magnitude, when in solid connection, by means of such a rod as this, with a valve-gear, twice in every stroke of the engine, from a height varying from two to three inches, falling upon the solid part of the engine, would make a practical working engine.

A. I do not think it would be a good engine.

Q. Would it be a practical engine?

A. No; they would not be likely to work an engine with 715
such a noise as that.

Q. Would not the jar consequent upon the striking of such weights, in that rapid descent, destroy the working parts of the valve, and its connections?

A. I do not think it would affect them any; the injury would be upon the weight itself, and upon its own rod. I do not think much, even, would be transmitted to the rock-

716 shaft, and I do not think the valve would be affected practically.

Q. Would it not produce a chatter of the surface of the valve upon its seat?

A. I do not think it would.

Q. Have you ever tried that experiment?

A. I have not, but I have heard of people who have.

Q. Would not that be injurious to the working of the engine?

A. Yes; so far as to allow the valve to cant at all.

717 Q. Is it not an object in the construction of all steam engines to avoid in every practicable manner jars in any part of the engine?

A. It is; in steam-engines or any other machinery.

Q. Is it not for that very reason that cams have ceased to be used for the purpose of cutting off steam?

A. No; I do not think it is. It is because we have got a better device for doing it.

Q. Was it not universally admitted to be a practical defect in steam-engines that the use of cams produced a jar in

718 the valve?

A. I am not aware of that; cams would necessarily produce great complexity in an engine.

Q. Do you not know that you can make a cut-off valve working by a cam with more simplicity in the connection than by any other known mode?

A. No, I do not.

Q. What is the purpose of that screw in the dash-pot of the defendants'?

A. By stopping up the hole, to let the air escape around

719 the weight only. You want to check the weight a little, so that it should not fall so rapidly as in a free space; and it is a kind of correction for bad workmanship.

Q. In other words, has it any other use in the world, but ause to the eye?

A. Yes, it has; in case the plunger is fitted too loose, you get a better movement of the part by closing the hole up a little.

Q. Do you know if that is used for the purpose of checking the valve during the working of an engine?

720 A. I have seen it used for that purpose. It is on the defendants' machine, or was when the original dash-pot was it.

Q. Do you know whether Youngs & Cutter ever use it?

A. That is the engine I refer to.

Q. After an engine has been put up and is working, is that screw ever used?

A. No.

Q. I will recall your attention to the cut-off motion. 721
Would it destroy the identity of Sickels' combination for tripping the valve, to substitute on this valve-stem for the puppet-valve, a straight sliding valve?

A. I think that if you could put a slide-valve that would work with that valve-gear, the first part of the invention would remain substantially the same.

Q. Would it make any change in the second part of the invention—the dash-pot arrangement?

A. I think it would.

Q. I want you to answer my question in reference to the 722
tripping apparatus?

A. I think you could put a plain slide-valve in there, that would work with the same valve-gear.

Q. Taking this piece of mechanism here, without any reference to the description of the patent, would the substitution of a slide-valve for a puppet-valve on this stem, make any material change in the dash-pot?

A. It would in its operation—in its construction it would not affect it.

Q. What alteration would it make in its construction? 723

A. It would not make any.

Q. What alteration would it make in its working?

A. There would be no longer a combination of that adjustable—

Q. Now, sir, you are going back to the specification; I am speaking with reference to this model here, as embodying this mechanism; when you have substituted the sliding valve on this stem for puppet-valves, what material change would it make in the operation of the dash-pot?

A. It will no longer prevent the valve from slamming. 724

Q. That is all?

A. Yes.

Q. Now, sir, when the valve is set in motion in one direction, must it not be stopped by something?

A. It would be stopped by some force—you would have to interpose something.

Q. Would not that something, when struck by the valve, or by the connections of the valve, produce a slam?

A. It would be likely to make some concussion.

Q. Would not that slam be injurious to the working of 725
the apparatus?

A. Probably it would.

Q. Is this dash-pot for any other purpose than simply to prevent that jar or slam, wherever it takes place?

A. The purpose is to act in combination with a particular kind of valve having a particular kind of engine, and made to act in combination with it, and provided with properties which will enable it to do so.

726 Q. Then your construction of this whole matter is, that if you take away from this entire apparatus the puppet-valve, and substitute any other kind of valve, the purposes of the invention are entirely changed?

A. The purpose of the last is entirely changed; but the first part will remain entirely the same.

Q. Would it be a substantially different piece of mechanism because the purpose was changed?

A. Taking the dash-pot by itself, the mechanism would remain the same; but in its combination with the valves,
727 its action would be different.

Q. Would it not arrest the valve?

A. Yes.

Q. Would it not prevent the slamming of the parts?

A. Yes, if properly adjusted.

Q. If the valve is closed by the force of a falling weight, would there not be a concussion in stopping it, unless you interposed something to prevent that concussion?

A. Probably.

Q. In both the defendants' and plaintiffs' arrangement,
728 is not the use of this mode of checking simply to prevent the injurious effect of that shock or jar by the stopping of the valve?

A. They are both for that purpose.

Q. Now, sir, is the construction or operation of the human legs entirely changed by the act of swimming, from a state of walking?

A. Not entirely, but very materially, I should think.

Q. Are you engaged in constructing steam-engines?

729 A. Yes, sir.

Q. What kind of cut-off do you use?

A. The slide-valve motion, which we get up in a way peculiar to our concern.

Q. Is there any demand in your section of the country for the tripping valve cut-off?

A. Yes, sir, they rank very high.

The Court then adjourned to January 3d, 1855, at 11 o'clock, A. M.

730 January 3d, 1855, 11 o'clock, A. M.

The *re-direct examination* of the witness, William C. Hibbard, was resumed.

Q. Will you state whether or not there are many kinds of valve-gearing used in steam-engines?

A. There are many, the character of each depending upon the general construction of the engine, and the kind of valve used.

Q. Are there or not several to the same kind of valve? 731
A. There are, in construction and arrangement.
Q. Are they or are they not substantially the same, or substantially different, as devices for the purpose of operating the valve, or as combinations?
A. As combinations for working the valve they might be, perhaps, more or less similar; and they may be, as simple combinations, different; of course, I must answer the question generally.
Q. Was there or not some kind of valve-gear known at the date of Sickels' patent, in which the valve-gear which 732
opened the valve did not also control its closing?
A. There was.

(*Mr. Keller* objected to this question, but the Court overruled the objection.)

Q. Were you acquainted with such kinds of valve-gearing at that time?
A. I cannot remember whether I was at that time or not; my knowledge is derived from descriptions in books, and from the testimony that I have heard given in relation to that subject. 733

(*Mr. Keller* objected to the witness stating anything that he had heard.)

Q. Were such kinds of valve-gearing described in the books previous to that?
A. There is one description, which is published in the books.
Q. In this machine of the defendants', if the stem was arranged below the exhaust-valve, so that the hook would rest upon the arm of the rocker-shaft, would there be any necessity for a spring to effect the connection? 734
A. There would not; it would engage without one.
Q. In that case, would or not a spring be entirely dispensed with?
A. It would.
Q. Would there or not, in that case, be any equivalent for a spring in that engine?
A. I am inclined to think that there would not be—that the power of nature cannot be held to be a mechanical equivalent for a device constructed by man. 735
Q. In the plaintiffs' model, as exhibited and described in the patent, can you place it in any position in which the connection will be effected by the force of gravity?
A. No, I think not.
Q. Was there any connection effected between the governor and the cut-off valves, which was practically successful, previous to that used by Mr. Corliss, to your knowledge?

Hibbard

736 A. I do not know whether there was or not; as I testified yesterday, there are several arrangements described, but how efficient they were I do not know; some of them I know are not; some I believe are not, from experiments I made in the same line myself.

Q. Have you ever known any to be in successful use?

A. I never have.

Q. Do you know when the check-ring, which has been alluded to, was first introduced?

A. I do not.

Q. Do you find it described in Sickels' patent?

737 A. I do not.

Q. Do you know of any valve-gearing used before that of Mr. Corliss, in which the motion of the connecting-rod which opens the valve—the lateral motion—was used for the purpose of detaching the valve?

A. I do not.

Q. Is that, so far as your knowledge is concerned, a new thing in that machine?

A. It is, so far as I know.

738 On being further *cross-examined*, the witness, William C. Hibbard, testified as follows:

Q. You have testified that the power of nature cannot be an equivalent for a mechanical device?

A. Yes, exactly so; I think it cannot be considered a mechanical equivalent, as part of a combination; it may be equivalent in effect.

Q. Is a weight a natural law?

A. It is another term for gravity.

739 Q. Is not gravity, as a law of nature, exerted upon the body which we call a weight?

A. It is.

Q. Is not the tensile force of a spring an instance in which the natural law of the elasticity of matter is developed?

A. Yes; it developes the law of elasticity.

Q. Then, sir, when you substitute a weight for a spring, do you not substitute one mechanical instrument for another
740 mechanical instrument—the one operating by one law of nature, and the other operating by a different law of nature?

A. You may sometimes do that.

Q. Do you not in this instance?

A. I think not; it is a nice question; I am inclined to think you do not.

Q. If you lay the plaintiffs' apparatus with the valve-spindle horizontal, and you put a weight so as to make the spring-catch heavy enough to work by gravity, instead of

working by the tensile force of the spring, will it not then 741
operate as well as by the action of a spring?

A. How will you put the weight?

Q. Make that spring-catch a jointed lever, for instance; would it not operate then by the force of gravity?

A. It would.

Q. Would it then not be an equivalent for the spring, for the purpose of engaging and disengaging?

A. It might, for the purpose barely of engaging and disengaging.

Q. Would it not operate as well as the rod in the defen- 742
dants', when turned upside down, without the spring, for
the purpose of engaging and disengaging?

A. I do not know but it might.

Q. Would it not then be working by the force of gravity?

A. The latch would then engage by the force of gravity.

Q. Now, with regard to Watt's valve-gear, described in
the books to which you have referred, was the valve-gear
operated from the eccentric, and having its regular motion
as it has in the case of opening and closing the valve? 743

A. It was not operated from the eccentric.

Q. Did it have that kind of motion which all valve-gears have that work engines at full stroke—always in connection with the valve-stem?

A. No.

Q. Did it have that motion backward and forward, and liberate the valve, and then re-engage it?

A. I do not understand the question.

Q. Did Watts' valve-gear have a regular motion, such as
is employed in the valve-gears that are now generally used 744
to open and close the port by a positive motion, and so
connected with the valve-stem as to liberate it at any
portion of the stroke of the engine desired—the valve-gear
continuing its motion and coming back to re-engage with
the valve-stem?

A. If I understand the question, I think it had not all those peculiarities of action which the question supposes.

Mr. Jenckes.—Do or not those valve-stems engage or
disengage in that operation? 745

A. They do.

Q. Were they or not so constructed and operated as to work the steam expansively?

A. They were, and could work it expansively or not, as desired.

Mr. Keller.—Where is it described, sir?

A. In a good many of the old books.

Q. Name one?

746 A. Tredgold.

Q. Cannot you give us a special reference to the description?

A. It is in the text of Tredgold, but I cannot remember the page. I think I can find it if you will give me time.

(The witness was allowed to retire from the stand, with an understanding that he should find the passages referred to, and should then be further examined in regard to them.)

The defendants then called as a witness—

747 *Mertoun C. Bryant*, who, being sworn, testified as follows:

Q. Where do you reside?

A. I reside at Lowell, Massachusetts.

Q. What is your occupation?

A. For the last ten years I have been employed as a mechanical engineer—a part of the time in the construction of mills and their machinery, and a part of the time in the construction and working of gas works.

Q. Have you or not acquired a practical acquaintance
748 with machinery?

A. I have.

Q. With steam engines?

A. I have seen steam-engines frequently at work, and have had occasion to take care of the starting and running of one.

Q. Have you ever been examined as a witness in the trial of patent causes?

A. I have, frequently.

749 Q. Have you read the patent and examined the specification and drawings annexed to the patent granted to Sickels in May, 1842?

A. I have, sir.

Q. Do you understand the description and specification and claim of that patent?

A. I think I do.

Q. Have you examined Sickels' black model?

A. I have, sir.

Q. Does that represent the mechanism described in the
750 specification?

A. I think it does.

Q. Have you examined this mahogany model of Sickels' apparatus?

A. I have, sir.

Q. What does that show?

A. It shows the apparatus described by the patent of Mr. Sickels, the same as the other model. It shows more fully the construction of the dash-pot.

Bryan

Q. From your acquaintance with the steam-engine, will 751
you state what was the usual way of operating the lifter and
the valve-stem in steam-engines, at or about the date of that
patent?

A. I cannot say that my practical experience is sufficient
to speak from my own knowledge what was the usual way;
but I know that an arrangement similar to this working
model, (Sickels',) was one of the ways.

Q. Do you know whether or not it was the usual way of
working puppet-valves?

A. I never have seen them worked in any other way.
The method there seems to have been that the steam-valves 752
and exhaust valves were attached to the same lifting rod.

Q. Have you seen the defendants' engine in operation?

A. I have.

Q. Have you seen other engines constructed upon the
same plan, in operation?

A. I have.

Q. Do you understand the construction and mode of
operation of those engines?

A. I think I do.

Q. Are they represented in the model of the defendants' 753
machine before you?

A. Very fully, I should think.

Q. Will you state, sir, whether, in your judgment, as a
mechanical engineer, the construction, arrangement or com-
bination of the apparatus used in the defendants' engine, for
more readily cutting off steam, is substantially identical
with the construction, arrangement or combination of the
apparatus used and described by Sickels in his specifica-
tion, for that purpose?

A. I do not think they are; the Sickels' apparatus seems 754
to me to have been a combination attached to the well-
known valve-gear, where the lifting-rod carried a lifter,
which, at that time, previous to the adaptation of the appara-
tus, was attached permanently to the valve-stem. The ob-
ject and intent of the arrangement, so far as detaching is
concerned, seems to have been, and the result seems to be,
that the valve-stem can be detached from that lifter at any
point of the stroke, from the first to the last. This arrange-
ment is adapted, from the first to the last, and the arrange-
ment particularly described, by which the wedges can be 755
reversed, is necessary for that purpose in this combination;
because, in the working of this valve-gear, the lifter reaches
its upper extent of motion at the time that the piston is at
half-stroke, and, during the time that the piston is making
the latter part of the stroke, the lifter is in its downward
descent; these latches and inclined wedges, by the elastici-
ty of the latches and the shape of the wedges, enable those

Bryant

756 parts to be so placed that the cut-off can take place either during the upward motion of the lifter, or during the downward motion of the lifter; the combination of apparatus seems to begin and end in an adaptation to the lifter, such as was well-known; it belongs wholly to that description of apparatus or valve-gear.

Q. How is it in the defendants' machine?

A. In the defendants' machine the valve-gear is not of the same construction or the same arrangement, and has not the same elements.

757 Q. Point out upon the model what you understand to be the difference?

A. You may see that these valve-gears have both the same object; the object of *this* valve-gear is to cut off at a determined and fixed point of action or a fixed point of the stroke; the Corliss' valve-gear is arranged generally so that it can be made to cut off at a variable point of the stroke; that seems to be the foundation of the two apparatus; and the great distinction between them as valve-gears, independent of their peculiar construction or peculiar adapta-
758 tion, is found in the fact that the Corliss' valve-gear is adapted to the regulator; the object of it is to cut off the steam at such a point that a proper velocity may be given to the machinery, and be governed by the regulator; the regulator is a very sensitive instrument.

Q. Is it necessary that it should be so?

A. It is so, and I do not know that it can be any otherwise; these balls, in the revolution of the engine, are set in motion, and they acquire a position, either down or up, according to the velocity; the higher the velocity, the further
759 the balls recede from the lowest point at which they can swing; this is just as delicate as when we suspend a weight by a string; we know that a weight suspended by a string requires very little force to move it, either in one direction or another; now, these balls, when they are in motion, are precisely in the same condition as to the actual force required to move them from that position, provided that the connections are sufficiently free, as the weight suspended by a string; we know that a very little force would move
760 that either one way or the other; and the same amount of force would move these balls up or down; it requires, on account of the delicacy and the ease with which they are moved, that they should be as free as possible. The apparatus here shown seems to follow that direction, that fact, throughout the whole of it; it is, to adapt the arrangement of the tripping apparatus so that it can be set or altered by this delicate governor; in order to do that, the governor must, as I said before, (and it cannot be said too often,) be as free as it is possible to make it with machinery. Now, then, the tripping apparatus must be such that there will

be very little resistance opposed to the movement of these balls, either up or down; it can be easily seen upon this model that all that the balls are intended to do—all the force which they must exert, and which must be exercised by them—is to move this sliding-rod. Here is the disconnection between the sliding-rod and these sliding-bars or stops; these sliding-stops are free to fall away from the sliding-rod; they are not attached to the governor. In the detaching of this apparatus there is a mere touch upon these stops, when the hook-rod comes in contact with them, by 761
which the two hooks, or the hook and catch, are thrown 762
apart from each other; that is accomplished almost instantaneously by the action of the hook-rod upon the stop—the hook-rod acting as a lever, and the stop acting as a fulcrum; that that is the action can be easily seen, because if this hook-rod were moved in *this* direction, away from the hooks, or from the hook and catch, it would not tend to throw off the hook from the catch.

Q. In which direction is that?

A. In a direction away from the hooks, if they both can
be said to be hooks; but if the movement of this hook at the 763
end on the wrist-plate should be vertical, then the action would be that the hook-rod would strike the stop, and be readily disengaged. The end upon which the hook is, would be thrown down and thrown away from the hook. That is the action that takes place—the hook-rod having two motions—one in the line of its general centre, and the other in a direction at right angles to that line. It moves in both directions. The movement in the direction from the hooks tends to open the valve; the direction at right angles to its

Hook rod motion

axis tends to unhook the hooks. Now, this leaves but an 764
instant of time at which the hook-rod comes in contact with the stop, and at which the movement of this sliding-bar is detained or hindered by the action of tripping. If this sliding-rod should be detained for any length of time during the running of the engine, and during that time the velocity of the engine should be increased or decreased, these balls upon the govornor would not be able to assume the position that they desire to assume—they would not be able to fall
or rise; but when they were released, their tendency would 765
be to assume that position very suddenly, and that tendency would throw them by and beyond the position that they ought to assume. They would acquire a momentum, if the engine were increased in velocity, so that they would be driven out beyond the point that was due to the speed of the engine at that time. Just the same as when we have a weight suspended by a string, and we move it out of its vertical position, it has a tendency to go back beyond in the other direction. This quality does not and can not exist in Sickels' arrangement. If we observe the upward part of

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766 the stroke when the valve is being lifted from his seat, these
springs engage with these wedges, and, during the time they
are engaged with these wedges, they present a resistance to
the movement of this wedge-shaped apparatus, which would
hinder and control the action of the governor, on account of
the friction there existing upon it. We see that there is a
distinct difference between the wedge action in *this*, and
the action over the fulcrum as a lever in Corliss'. Probably
one of the most delicate instruments in which levers are
used is the piano-forte. It is easily conceived that the keys
of a piano-forte might be moved by a series of wedges, but
767 it would destroy the delicacy of action which is necessary
to the complete operation of the instrument. Just so, I
conceive, the delicacy of action of the governor in this
machine would be destroyed by the operation of the
wedges, as described in the Sickels apparatus. There is
another point, which arises from an entirely different view,
which is with reference to the admission of steam into the
cylinder, to which Corliss' apparatus is arranged, designed
and adapted particularly, which does not come into play or
into action in Sickels' apparatus. It is an object that steam
768 should be delivered to the cylinder as near the actual force
which it has in the boiler as possible, in order to arrive at
its full effect, especially when used expansively. That has
been fully explained, and I suppose I need not say how the
effect of using steam expansively is produced.

Q. Go on, and show how it is obtained in Corliss' machine?

A. Steam should be received into the cylinder at the
highest point of pressure possible, and, in order to do that,
it is necessary that the valves which admit the steam should
open very suddenly, and the quicker they open the better
769 the effect. In Sickels' apparatus, it is impossible to open
them very suddenly, or so suddenly as they can be in
Corliss', on account of the construction of the valve. It is
a puppet-valve which rests upon its seat, and is lifted
away from its seat. It is found, in working this kind of
valve, that, on account of the pressure of steam upon it, it
becomes very difficult to work; therefore, they use what
they call the balanced valve, by which the pressure is re-
lieved somewhat, so that the valve is more free to be lifted
770 from its seat; but the style, in all constructions, as I un-
derstand the plan to be, is to make the valve so that
there is more pressure towards its seat than from its seat.
This arrangement of the balanced valve is to relieve the
difficulty that existed where there was one; but, in intro-
ducing two, we bring in another difficulty, which is, that
there is more weight. In the construction of puppet-valves,
there must, of necessity, be a considerable weight to the
valve. So far as that has any effect on the detaching
apparatus, it is this—it cannot be opened quickly, because

there is a certain *inertia*, as it is called, which can be over- 771
come gradually and quietly, but which cannot be suddenly and directly put in motion. That is one of the reasons why this valve cannot be opened suddenly. The weight is doubled by the peculiar construction rendered necessary to open the valve freely. This weight has to be put in motion. It cannot be done suddenly without a great shock. Perhaps I may go on further, and say, that the puppet-valve, when it is opened, must be opened from a state of rest. It arrives at a state of rest when it is completely shut, and, as soon as
it is moved from that point, it must commence to open. 772
That is peculiar to puppet-valves. The same thing with regard to the starting of the valve is true of the Corliss engine; but there is this peculiar result—the motion of the valve does not of necessity suppose an admission of steam into the cylinder. The valve is started slowly from a state of rest, and increases its motion for a certain length of time. Meanwhile it has not reached far enough to admit the steam into the cylinder; but an advantage is taken of this time, to accelerate the motion of the valve, and, when the proper time does arrive to admit steam into the cylinder,
the valve is then under considerable velocity, and, of course, 773
can open the inlet more suddenly than if started from a state of rest. These two great features seem to make a vast distinction, so far as the operations of the two engines are concerned.

Q. Will you examine that piece of machinery (part of the working machinery of Sickels' apparatus, from the De Laine Mill,) and state what that is?

A. This seems to be an apparatus for raising the valve and detaching it from the lifter. The detachment, as I un-
derstand it, is effected by the disengagement of this latch 774
from the stem. There is a groove turned in the stem. The latch is made so that it enters and disengages—can enter and be disengaged—from that groove. When the latch is in the groove, then the lifter is attached to the stem; when the latch is out of the groove, then it is detached from the stem. The latch is thrown into the groove by a spring, which is in *this* place.

Q. Does not the condition in which you find those parts show that a considerable degree of power has been made
use of to effect the disengagement? 775

A. This I suppose to be the standard which the latch encountered in rising. By the position of this standard, having this conical-shaped surface upon it, the latch would strike against the wedge surface, and throw out the end which entered into the valve-stem. The conical surface shows indications of having been worn in a number of places. It looks as if it had been worked in one position and then turned around to another.

776 Q. Does or not that show any practical difficulty in connecting it with the governor?

A. It would show the same difficulty that I have explained, or tried to explain; that during the time the latch is engaged, with *this*, there is an amount of force resting upon it which would take away the effect produced by the governor.

Q. In cutting off beyond half-stroke, would that pressure be increased or diminished upon the black model?

A. The effect is increased, because, in going up, the spring
777 catches encounter the wedge-pieces, and in coming down they do the same. They have double the effect when the detachment is effected beyond half-stroke.

Q. Do you, or not, find in the model of the defendants' engine any valve-box containing puppet-valves?

A. There are no puppet-valves in the defendants' engine.

Q. Are there any valves which are to be lifted from their seats?

A. There are none.

Q. Do you find the construction of those parts such as is
778 commonly used for puppet-valves?

A. I never have seen any puppet-valves worked with an arrangement like that in Corliss' model.

Q. Point out upon the black model (Sickels') the valve-stem.

A. The valve-stem here, and as described in the patent, is a rod which is permanently attached to the valve, and extends out.

Q. In which direction does it move?

A. It moves towards and from the seat of the valve, or in
779 a vertical direction.

Q. In the direction of its own length?

A. Yes.

Q. Do you find any valve-stem upon the defendants' model which is moved in the same direction?

A. There is none—there is no valve-stem.

Q. Do you find, in the defendants' model, any lifter which is constructed and "acted upon in the usual way?"

A. In the defendants' there is no lifter, such as is described in the Sickels specification, or such as was ever
780 seen before this arrangement was completed, as I suppose.

Q. Do you find any spring attached to the shaft of the lifter or any other part of the valve-gear, the outer end of which embraces the sides of the valve-stem?

A. No such apparatus as that.

Q. Do you find any valve-stem, or anything connected with the valve, which is flattened or has projecting edges or feathers, as in the small black model?

A. There may be a great many things about the valve

which are flattened and have projecting edges. There is 781
no connection on the valve-stem, which has a flattened or
projecting edge in the defendants'; because I do not consider
that there is any valve-stem.

Q. Do you find any valve-stem, or anything connected
with the valve, in the defendants' model, which rests upon
any spring?

A. No, nothing of that kind.

Q. Do you find any spring sustaining the valve when
opened, which, when unlatched, will permit the valve to
descend? 782

A. There is no such arrangement, by which the opening
of a spring-catch will allow the valve to descend, in the
defendants'.

Q. Do you find any apparatus in the defendants' model
by which the valves may be tripped at any time during the
ascent or descent of the lifter, and thus cut off steam at any
part of the stroke of the piston?

A. There is an arrangement in the defendants' by which
the valve can be tripped at certain periods of the movement
of the piston up to half-stroke, but beyond that there is no
apparatus to accomplish that object. 783

Q. Do you find in the defendants' machine any standard
rising from the valve-box, as in the plaintiffs' black model?

A. There are standards—a number of them—rising from
the valve-box, or the box which contains the valve.

Q. Is there any standard holding a set screw?

A. There is no standard for that purpose.

Q. In the black model of Sickels' machine, will you explain the operation of the spring on the lifter by which the
detachment is effected?

A. The spring upon the lifter is an elastic substance, the
tendency of which is to pinch the valve-stem; that same 784
elasticity is extended out and beyond the lifter, so as to engage with the wedge-pieces which are attached to a standard; the springs are elastic between the stem and the lifting-rod upon the lifter, and are also elastic between the valve-stem and the standard which supports the inclined wedges.
The elasticity between the stem and the lifting-rod is necessary
in order that it may engage and disengage with the valve-stem; the elasticity between the valve-stem and the standard is necessary, in order that it may pass and repass by the
wedges; so that, during the whole length, the springs, in 785
order to have a complete action, must necessarily be elastic;
when the lifter is raised, and the cut-off set at a fixed point,
the ends of the spring strike the inclined wedges, the first
tendency of which is to bend the springs outward and inward; the friction or weight of the valve-stem would cause
the elasticity of the springs to be extended from and be-

786 tween the wedges and the valve-stem, and those springs would require a certain amount of tension, and, as the lifter went on, would finally be thrown out of the notches in the valve-stem quite suddenly.

Q. Will you explain the operation on these models, (skeleton models of spring-catch.)

A. *This*, I suppose, is intended to represent the valve-stem, and *this* the inclined wedge; this does not represent the action fully of the springs, but it is a combination of stiff latches made to work by springs. (The witness ex-
787 plained the action of the models, and continued:) This shows that there are two actions to this spring, if nothing more—one between the stem and the incline, and another between the stem and the lifter, or the valve lifting-rod, which allows it to disengage or fall out; the other action which takes place by the bending of the spring between this point and the end, will not take place in this as it will in the elastic spring.

Q. Do you find any such device or any such mode of
788 operation, or any equivalents for them, in the defendants' machine?

A. There is no equivalent for the spring acting as I have described.

Q. Have you examined the working of the defendants' machine, or of machines built like it, for the purpose of testing the effect of the machine in using steam in the manner that you have described?

A. I have; I have seen two or three such engines at
789 work, and made experiments upon one, to ascertain what the effect of the steam was.

Q. Will you state in general terms what the result was?

A. The result was that the steam in the cylinder was within two pounds pressure of that which was in the boiler.

Q. At what period of the stroke?

A. The first part of the stroke.

Q. How long did it continue?

A. It continued until the time of cut-off, and afterwards decreased, by its expansion.

790 Q. In that machine, and in the other machines that you have examined, what determined the point of cut-off?

A. It was determined by the governor.

Q. What conditions affected the action of the governor?

A. I before said that the governor should be free to move; the balls of the governor should be free to move in either direction, and not be countervailed by any other force than their velocity.

Q. In other words, what conditions affected the velocity of the engine?

A. The velocity of the engine is affected by a number of 791
conditions—the amount of work to be done; if the engine
remains in the same condition otherwise, putting more work
on would reduce the velocity; if, with the same amount of
work, the pressure of steam is increased, it will increase the
velocity; if, with the same amount of work and the same
pressure of steam, an admission of steam, so that it shall
follow at full pressure the full stroke of the piston, would
make an increased velocity.

Q. What is the mode of regulating engines constructed
differently from that of the defendants? 792

A. I think the most common method is to regulate by
a throttle-valve.

Q. How is that throttle-valve worked?

A. It is usually connected with the governor.

Q. Where is it placed?

A. It is placed in the steam-pipe, between the boiler and
the cylinder.

Q. How does it produce the regulation of the engine?

A. It reduces the pressure of the steam by wire-drawing
it, as it is termed; the steam has to pass through a smaller 793
orifice, to produce a less velocity.

Q. What effect does that have upon the working power
of the steam?

A. It reduces the power, which, by using an expansive
power, would otherwise be obtained.

Q. Do you know as a fact to what extent it is reduced in
engines in common use?

A. It is reduced to a variable extent; because, as the
steam increases, the same amount of work being done,
there must be some difference between the steam in the
boiler and the steam in the cylinder. 794

Q. Do you know within what limits it is usually found?

A. I do not know how much difference there would be
usually. It depends altogether upon circumstances.

Q. Through what portion of the stroke of the piston does
the rod which opens the valve come in contact with the
stop which detaches?

A. Some parts of the time steam will follow the piston
one-eighth and from that to nearly one-half of its stroke.

Q. Have you ever examined an engine in a rolling mill?

A. I saw an engine in a rolling mill. 795

Q. Whose engine was it?

A. I do not remember the name.

Q. Was it an engine constructed like the defendants'?

A. Yes, sir.

Q. Did you see the operation of the governor, in connection with the cut-off in that engine?

A. I noticed it very particularly.

796 Q. What was the engine doing—what was the work upon it?

A. They were rolling brass plates. It was observable that every time the plates were presented to the rollers, the governor instantly gave the cylinder more steam, and they were changing every minute.

Q. What was there upon the engine while the bars were not in the rolls?

A. So far as I could see, merely the necessary apparatus to control the power.

797 Q. Does that require a small or a great degree of power?

A. Small.

Q. When the bars were in, what was the degree of power?

A. Then a considerable amount of power was required.

Q. Does it not vary very substantially?

A. Yes; from a very small to a very great power.

Q. During what space of time?

A. I think it is instantaneous.

Q. What length in the variation of cut off have you seen in the operation of that engine between one stroke and
798 another, or between the engine when the bar was not in it, and when the bar was being rolled or pressed?

A. I have seen it cutting off when there was no rolling, probably steam being admitted into the cylinder until the piston had gone one-sixth or one-eighth of its stroke. When the bars were in, and the plates were rolling, steam was admitted until the piston had followed probably one-third of its stroke. I did not measure the parts so as to be able to state particulars; but that was the result that I arrived at from observation. Sometimes it would seem as if there
799 was no steam admitted, which I think was the case.

Q. Can you illustrate the effect on this model in any way?

[Witness illustrated.]

Q. What did the first condition represent in rolling?

A. The first condition represented, is where there is very little force necessary to move the apparatus; the last condition when great force is required.

Q. It was controlled in a very short space of time?

A. It was adjusted and controlled instantly by the governor.

800 Q. Are you acquainted with the mode of regulation in other rolling mills, using different kinds of engines?

A. I never examined them particularly.

Q. You spoke of the valve in the defendants' machine being open more or less, according as the cut-off is effected near the beginning of the stroke or further from it. How was steam admitted into the cylinder at such times—with greater or less tension?

A. Steam is admitted into the cylinder at very nearly the same tension at all times. The opening of the valve at the first point of opening is very small, and the velocity of the piston is also very small, so that the proportion of the opening is very near to the wants of the cylinder; and, when the piston is at its greatest motion, then the construction of the valve is such that it is wide open. 801

Q. Does it or not then practically make a great difference in the defendants' engine whether the valve is opened entirely or only partially at the commencement of the stroke?

A. All that is necessary is, that there should be a sufficient opening, so that the tension of the steam will not be reduced when it reaches the piston. That was the case in all the experiments that I saw. 802

Q. How many experiments do you refer to?

A. I should think a dozen, made under different circumstances.

Q. Under what change of circumstances did you make these experiments?

A. A change in the tension of the steam and in the pressure of the steam in the boiler. 803

Q. How great a variation in the pressure of the steam?

A. Thirty pounds.

Q. In the mode of detaching in the defendants' machine, do you find the wedges or inclined planes, or any equivalent for them?

A. I think there are no wedges or inclined planes, or any action of a wedge or inclined plane, so far as detaching goes, in the defendant's engine. 804

Q. How would you express the difference between the action of the two in that respect?

A. The action of the wedges in the plaintiffs' is a continuous action, by which friction is produced. In the defendants' the action is simply that of a lever over a fulcrum. One has qualities which the other has not; as I have tried to explain, those qualities are necessary to the action of the defendants' combination, and in the plaintiffs' they are not necessary.

Q. Have you ever seen or known a lever to be used for the purpose of detaching in any other machine than in the defendants'? 805

A. I think I have.

Q. Have you examined the description of the second part of Sickels' invention?

A. I have.

Q. Will you describe upon the model what it is, and what the purpose of it is, as you understand it?

A. This wooden model exhibits the apparatus described

Bryant

806 in the second part. The puppet-valves are made tight by resting upon their seats. There is a nice point of adjustment. The valve, when it closes upon its seat, should be perfectly steam-tight. In order that it shall be so, the surfaces being metal, it is necessary that those two surfaces of the valve and of its seat should be kept in a perfect condition —made perfect in the first place, and kept so. Now, it seems to me that the object in that, and which is described as being in that by the second part of Sickels' patent, is
807 principally to prevent any damage which would necessarily result by the falling of these valves upon those seats, which result would be that the two surfaces, of the valve and of the valve-seat, would be abraded, and thereby the valve would leak, if the surfaces were uneven. That would result from the slamming of the valve. The valve, it will be noticed, as I said before, is double, and of course must be of considerable weight. That is not all. It is also made in such a way that, in addition to the weight of the valve, tending to shut it, it has a force of steam tending to shut it. Al-
808 though said to be balanced, it is always the custom to make the upper valve larger than the lower one, so that the pressure of the steam upon the valve will tend to close it. This additional pressure tends still more than the weight of the valve to jam and abrade its surface and the valve-seat, where they come in contact. Now, in order to avoid that difficulty, this apparatus, called a dash-pot and a piston, is made. It consists of a cylinder for water, the upper part of which is somewhat larger than the plunger. Near
809 the bottom of the cylinder of water is what is called the secondary cup, which approaches more nearly to the size of the plunger. This cup is shown as being a conical cup, shaped like a cup we drink tea out of; so that, as the plunger enters the top of the cup, there is more space between the inside of the cup and the plunger than there is when the piston has reached nearly to the bottom. That seems to me the construction as shown. It would tend, after the piston had entered the cup, to shut off, by degrees, the opening through which the water flowed from under the plunger; that is, the outer edges of the plunger would
810 gradually approach the inner side of the cup. The cup is conical. This cup is made adjustable, and there are two very good reasons why it should be so, as I suppose. The valve has to be stopped at a precise point. The plunger cannot rest upon the bottom of the cup; because, if it did so, it would hold the valve up from its seat, which would be an objection. Now, there is a nice point to which it is necessary to arrive, in order to present just sufficient resistance to the plunger which is attached to the valve, so that the valve shall reach its seat quietly and without a concus-

sion or slam. The difference in the height of the falling of 811
the valve would give it a greater force, and to adjust it accurately would require a different position of the adjustable cup. The weight is one of the causes by which the valve is closed. The other is due to the increased tension of steam acting upon the top of these valves to press them down after they are detached and the weight falls. This secondary cup, to work completely, would require adjustment. It is made adjustable in connection with the inclined planes;
because, as the inclined planes are higher up, and the valve 812
would fall farther, it would require greater resistance to control it, or stop it, by the secondary cup.

Q. Is that or not necessary to the proper adjustment of the tripping apparatus for puppet-valves?

A. I think it is necessary to this mode of working the tripping apparatus.

Q. At what point is the valve checked in its fall in Sickels' model?

A. It is checked very near the point of closing.

Q. Before the point of closing? 813

A. Certainly; it is checked before the point of closing.

Q. Is there any regulation of the descent of the valve into its seat, in Sickels' model?

A. It is regulated by the position of the secondary cup.

Q. Is there or not any necessity for such regulation in that model?

A. I have no doubt but that the valves would go to their
seats without any such regulation; so that it cannot be said 814
to be a matter of necessity, so far as the closing of the valves are concerned. But, so far as closing the valves to prevent them from slamming, there is a necessity.

Q. Now look at the defendants' model, and state what you find there?

A. His valves are closed by a weight attached to an arm on this rocking-shaft. The weight is lifted by the hooks, and falls into a reservoir or cylinder containing air. The air-cylinder, or, you may say, the weight which closes the valve, is formed as a piston, that enters the cylinder, and
very nearly fills it. Near the bottom of the cylinder is an 815
outlet, covered by an adjustable screw, which controls, or can be made to control, the falling of the weight. The action of the weight is to shut the valve. The action of the cylinder is to prevent the slamming of the weight in the bottom of the cylinder. The weight always reaches the bottom of the cylinder in one extent of motion. The valves are not puppet-valves, and cannot slam.

Q. In your opinion, as a mechanical engineer, is the construction and arrangement of the apparatus used by the

816 defendants identical with the construction, arrangement and combination described in and claimed by the complainants under Sickels' patent—substantially identical?

A. I think that the apparatus described in Sickels' patent is an apparatus for preventing the slamming of the valves, and applied to puppet-valves; the apparatus used by the defendants does not employ puppet-valves, and it does not use a valve that can slam; therefore, the apparatus is not used for the same purpose; in one case it is used to check the falling of a weight, and in the other it is used to prevent
817 the slamming of the valves.

Q. Is there or not any regulation for the closing of the valves in the defendants' machine?

A. By the adjustment of a side-screw, shown in this large model, the velocity of the weight and the corresponding velocity of the valve would be regulated to a certain extent.

Q. After the position of the parts is once adjusted in the defendants' machine, is there any necessity or any advantage in altering them to suit the altered condition or working of the engine?

818 A. I do not think there would be; the limit of the motion is controlled by the bottom of the dash-pot into which the weight falls in the defendants' engine; that is fixed, so that the hooks on the hook-rod and on the arm will engage with one another; limit the position, or bring it to such a position that they will engage—that is all that is necessary; no conditions will arise in the working of the engine similar to or dissimilar from the plaintiffs', to require an alteration amounting to an adjustment.

Q. Have you examined the working of this apparatus in
819 the defendants' machine?

A. I have seen it at work.

Q. Do you know in what position the weight was when the port was closed, or before it was closed, or just closed?

A. I was shown, by Mr. Clark, some marks upon the engine, which designated the position at the time the valves were closed; assuming these marks to indicate the position of the valve, then the weight was about one-half or five-eighths of an inch above the small outlet hole on the side of the cylinder, when the port was closed; and, after the
820 port was closed, the weight fell the rest of the way to the bottom of the cylinder.

Q. How far did the weight move after the port was closed?

A. I think the weight fell about an inch; it might be an inch and a half, perhaps more; I do not know how far it is from the hole to the bottom.

Q. At what point of the fall of the weight would its speed be essentially checked by the operation of that cylinder?

A. It would be checked after or at the time the hole in the side was passed by the bottom of the plunger. 821

Q. Do you find in the defendants' apparatus any secondary reservoir or adjustable cup, similar to that in the plaintiffs' model, or any equivalent for it?

A. There is, in the bottom of this, a part where the weight is resisted to a greater extent than it is during the other part; it acts to check the weight and prevent it from striking the bottom of the cylinder, as a sort of cushion; it does not act to prevent the slamming of the valves.

Q. Have you ever seen it working with any other substance than air beneath the weight? 822

A. I never have.

Q. Have you seen the weight, in the defendants' machine, fall upon other substances?

A. I have seen the weight fall upon a piece of carpeting or leather, which checked the fall of the weight and prevented its hammering.

Q. How did the apparatus work in that mode of checking the weight? 823

A. It worked just as well as with any other mode; all that is necessary is something to stop the weight.

Q. In the plaintiffs' model, is it or not necessary to have the connection between the valve and the plunger rigid?

A. It is.

Q. Why?

A. Because the whole object of the pressure is to sustain the valve.

Q. Is it or not necessary in the defendants' apparatus? 824

A. It is not necessary in the defendants' apparatus; in the defendants' apparatus the valve is quite free to move until the port is closed.

Q. Have you ever seen it working with a loose connection?

A. I have seen it working with a leather strap between the weight and the arm, and a string between the weight and the arm.

Q. How did it then work, as compared with the rod?

A. It worked fully as well as with the rod; all the object of the weight is to pull the valve in one direction; there is 825
no need of any connection between the weight and the valve which will act in the other direction, that is, from the weight towards the valve.

Q. When the connections are loose, is there or not any jar communicated from the weight to any portion of the valve-gearing?

A. There could not be any jar communicated back through the strap or string.

Q. Do you know whether or not there are other devices for arresting slamming or jarring in machinery?

826 A. Other devices than what?

Q. Than these two.

(*Mr. Keller* objected to the question.

The Court held that the inquiry should be allowed only so far as it tended to show a dissimilarity between the apparatus of the defendants and that claimed by the plaintiffs.)

Q. Do you know of any device used for the checking of a falling weight in machinery?

A. I do.

Q. What are the elements of such a device?

827 A. A cylinder, a plunger falling into it, and water in the cylinder.

Q. How old is that device?

A. It is described as being used in Watt's engine.

(*Mr. Keller* desired the Court to note that he would claim the right to introduce rebutting testimony in relation to this part of the case.)

Q. Do you know of any device in the steam-engine itself by which the motion of any part of it is arrested or checked by an elastic fluid?

828 A. It is usual in locomotive engines—common at least—to admit a portion of steam forward of the piston, in order that just before the piston arrives at its full length of stroke, the momentum acquired by the piston shall be resisted by the steam between the piston and the ends of the cylinder, to check the momentum.

Q. Do you know whether or not that was used in a single acting engine, for the purpose of checking the descent of the piston?

A. It is described as being so used.

829 Q. How did it check the descent of the piston?

A. A quantity of steam was confined in a space which the piston was trying to fill, and the steam and piston could not be there at the same time, so that the piston was checked.

Q. Suppose that you place in the plaintiffs' machine pieces of carpeting or other substances which you have described, instead of the water in the reservoir, how would it work then?

A. If they were elastic, as carpet is, the valve would strike its seat with some force or else the material would

830 prevent it from resting upon its seat.

Q. Would the description of the first part of this invention of Sickels, as given in his specification, teach you or any intelligent mechanic how to construct the valve-gear and detaching part of the defendants' engine?

A. I do not think it would.

Q. Could it be constructed from this description, without the use of invention?

A. Not by any means. 831

Q. How is it in the second part of the invention, described in the second part of Sickels' specification; would the description there teach you how to construct the air cylinder used by the defendants?

A. To follow the description, you would not make an air cylinder like that.

Q. Can you find in this description any indication that air, or any other elastic and expansive fluid, could be used in such a contrivance as is here described?

A. I do not think that the description, taken as a whole, 832
conveys any idea that air or any elastic fluid was used or intended to be used. That appears very distinctly from the fact that he states "the cylinder is to be *part* filled with fluid."

Q. Does the mode of operation describe the escape of an incompressible fluid or of a compressible and elastic fluid?

A. The whole description refers to an incompressible fluid and liquid.

Q. Have you seen a reservoir used for the purpose of checking the fall of the weight in the defendants' machine, constructed with an open cup, or guides to the weight? 833

A. At Youngs & Cutters' I saw a cylinder like the defendants', having four slots in the side, of about three-quarters of an inch in width, cutting through the complete surface of the cylinder up and down, so that there could be no air confined under the weight. They served merely as guides.

Q. How did they work?

A. Very well.

Q. State how pieces of carpet or other material were placed in that dash-pot?

A. The cylinder was cut out in slots, so as merely to 834
form a guide. A piece of carpet or leather was placed upon the bottom of the cylinder, and extending up so that the bottom of the piston could not fall to the bottom of the slots.

The Court here adjourned until January 4th, 1855, at 11 o'clock, A. M.

January 4th, 1855, 11 o'clock, A. M.

The *cross-examination* of the witness *William C. Hibbard*
was resumed. 835

Q. Mr. Hibbard, will you now give the authorities to which you referred in your testimony yesterday, where you find the dash-pot and valve-gear described to which you alluded?

A. They are more particularly described in a public work entitled "The Steam Engine, its invention and progressive

22

836 improvement, an investigation of its principles and its application to Navigation, Manufactures and Railways, by *Thomas Tredgold*, Civil Engineer, volume I," at page 224, Article 478, and at page 261, Article 546, and illustrated on Plate IX, in volume II of that work. Those descriptions are as follows:

(Page 224, Article 478.) "*Modes of opening and closing valves, cocks and slides.*—The motion may be given either from the reciprocating or from the
837 rotary parts of an engine. In engines which have no rotary parts, motion is communicated to the valves by a rod or beam, called a plug tree, attached to the engine beam near to the end moved by the piston rod. This plug tree is provided with certain adjustable projections called tappets, which strike the levers or handles of the valves, and thus open or shut them at the proper intervals, as the beam ascends or descends. These handles turn on axis and act as levers to move the valves, slides or cocks. * * * * When valves are employed, they are generally opened by weights. * * * * A weight *w*, suffi-
838 cient to overcome the friction and open the valve, acts by a short arm *a*, on the axis which requires to be turned to move the valve; the weight is kept suspended by a spring catch *b* while the valve is closed, and when the catch is disengaged by the handle *c* being moved by the tappet *d*, the valve opens. If the valve be large it requires a considerable weight *w* to open it against the pressure of the steam, and in that case either the valve described in Art. 442, or Watt's mode of relieving the pressure may be adopted. It will naturally be inquired why weights are used to open the valves instead of using
839 the direct power of the beam. The only reason assigned for so doing is, that a weight opens a valve more rapidly, and the loss by closing them slowly was not quite so readily detected, though the absolute loss is about the same, and the practice is becoming more common to open them by direct action. The descent of the weight which opens a valve is regulated by an ingenious method. It either descends into or forces a piston into a vessel of water, (see C, Fig. 3, Plate 9,) while the aperture by which the water escapes from under it, may be increased or diminished at pleasure. The weight, therefore, acts with its full force to open the valve but as soon as it begins to move it is re-
840 tarded by the water till it be finally stopped. During the ascent a valve opens inwardly at the bottom of the vessel, and therefore the engine has not more than the weight to raise again."

(Page 261, Article 546.) "*To regulate by working more or less by expansion.*—This may be done by adjusting the motion of the steam valves, so that they may be closed at an earlier or later period of their stroke, according as the engine has less or more work upon it. This method is confined chiefly to regulating by hand. (See Article 481, and Plate IX.) The self-acting regulator in use applies with good effect only to valve engines, as neither the common
841 slide nor cock can be adjusted otherwise than to close the passage to the condenser. (See Art. 448 and 456.)"

They are also described in a public work entitled "A Treatise on the Steam Engine, Historical, Practical and Descriptive, by *John Farey*, Engineer," at pages 457, 527 and 528, and 530, and illustrated on plates XIII and XXIV. Those descriptions are as follows:

842

(Page 457.) "The structure of the working-gear has been already sufficiently described to give an idea of its action. The four short levers which are fixed upon the two axes *t* and *u* for the handles *r* and *s*, are so arranged that when the valves are all shut, these levers will assume the same direction as their rods 10, 11 and 13, 14, by which they are connected with the other longer levers, on the axes of the sectors for the different valves. The levers 12 and 16 are so regulated to the catch 3 as to detain the handles when the levers are in those positions, as is shown in fig. 10. The chocks 1 and 2 on the

plug-rod *l*, are adjusted so that they will just move the handles *r* and *s* into those 843
positions, in order that the catch 3 may retain them where the chocks leave them. When either of the handles is released from the catch 3, the weight 4 or 15 belonging to that handle will fall, and will open the corresponding pair of valves. In that action the weight has a great advantage of leverage to lift up the valves, as is stated, p. 374.

The valves must be opened and shut by hand in order to stop or start the engine, or to regulate its motion; and for this purpose, the attendant always retains a full control over all the four valves, by means of the two handles *r*
and *s*, either to open or to shut either pair of the valves, whatever position 844
the chocks 1 or 2 of the plug may be in; for even when either of these chocks has moved the handle belonging to it, so as to shut one pair of valves, they may, nevertheless, be opened again immediately by the same handle, without waiting for the return or removal of the chock from that handle. This is done by moving the handle still further in the same direction as the chock has just moved it; for, when the valves are shut, the short levers ont he axes of the handles, being in the lines of their connecting rods, those levers will have the effect of opening the valves, when they are turned in either direction from
that position. In the regular action of the working gear when moved by the 845
chocks, the valves are closed by the motion which those chocks give to the handles, and are opened again by the fall of the weights 4 and 15. Nevertheless, when the engine is regulated by hand, that action may be reversed, if required; for the same effects may be produced by the contrary motions of the handles, and then the weights will tend to close the valves instead of to open them.

This property of Mr. Watt's working-gear is very important, for although the four valves are moved with great certainty by the self-action of the
engine, still they always remain under the control of the attendant, who can, 846
at any time, give either two of the four valves, or all the four, an opposite position to that which the self-action would give them; or he can give them the same position, or any intermediate position, as the case may require."

(Pages 527 and 528.) "The catch which Mr. Watt used in most of his rotative engines, during the first ten years, is different from the diagonal catch which is described in p. 452, and represented at 3, 3, fig. 10, plate xiii. The catch is poised on a small horizontal axis, which is placed behind the axis *t u* of the two handles, as is shown at 19, fig. 13. The catch 3, 3 stands in
an upright position, and the end of the lever 12 of the axis *t* of the upper 847
handle is adapted to lodge upon the upper end of it; or the end of the lever 12, of the axis *u* of the lower handle, is adapted to lodge beneath the lower end of the catch, as is shown in the figure; but both levers cannot catch at the same time.

This catch is situated quite at one side of the working-gear, in the same relative position as the diagonal catch 3 in fig. 6, and the axis 19 of the catch extends all across the working-gear; a lever 20 is fixed to that axis, at the middle of its length, and extends forward horizontally, so that the extremity is close behind
the plug-rod *l*. Two small chocks which are fixed at the back of the rod pro- 848
ject out so much as to intercept the extremity of the lever 20; one of these chocks lifts the end of the lever 20 a little up every time that the piston reaches the top of its course, and that removes the upper end 3 of the catch backwards, so as to release the lever 12 of the upper handle, in order to allow the upper steam-valve, and the lower exhausting-valve, to be opened by their weight 4, as in fig. 8. The same motion of the catch 3 brings the lower end of it forward, in order to catch the end of the lever 16, which has been previously placed in the position shown in the figure by the operation of the chock 2 of the plug-rod *l*, when it raises the lower handle *s*, in order to close the lower steam-valve *e* and the upper exhausting-valve *h*.

As the piston descends, the chock 2 quits the lower handle *s*, but the lower 849
end of the catch 3 will detain the lever 16, so as to prevent the handle following the chock, until the piston arrives at the bottom of its course. The chock 1 of the plug then depresses the upper handle *r*, so as to close the upper steam-valve *b* and the lower exhausting-valve *l*; and, after that, the small chock at the back of the rod *l* depresses the end of the lever 20 so much as to

850 move the lower end of the catch 3 backwards, and then the lever 16 becomes released, in order that the lower steam-valve *e* and the upper exhausting-valve *h* may be opened by their weight 15, as in fig. 9, in order to produce the upward stroke of the piston. At the same time, the upper end of the catch 3 being brought forward beneath the end of the lever 12, will retain that lever in its position after the chock 1 rises from the upper handle *r*.

The operation of the working-gear with this catch is precisely the same as with the diagonal self-acting catch, fig. 10, in which the action of latching one lever discharges the other, as already described, (p. 452); but on the plan of
851 fig. 13, the catch is governed by the plug itself, independently of any other part of the working-gear. This kind of catch insures that one pair of valves shall be completely closed before the others are opened, because the different chocks on the plug-rod must, of necessity, be so regulated as that one of the handles of the working-gear shall be moved into their required positions before the catch is moved; and if this is not the case, the levers 12 or 16 will lock the catch fast, and prevent its motion, whereby the lever 20 will be strained, or some part of the catch work will be broken. This kind of catch is incapable of retaining all the four valves shut at the same time, which is a
852 great security against accidents; but when the engine is required to stand still, the two handles must be held fast by means of a short iron rod, with a hook at each end, and the hooks are applied to the two handles, so as to keep the lower handle up and the upper handle down. This was thought an inconvenience by the engine-keepers; and also, if they suffered the chocks to get loose and out of adjustment, the catch-work would be broken; hence Messrs. Boulton and Watt adopted the diagonal self-acting catch, fig. 13, which is free from those minor inconveniences; but it is liable to a much more objectionable accident, for it is capable of retaining all the four valves closed, whereby the
853 steam may by accident be confined in the cylinder when the engine is working at full speed."

(Page 530.) "Plunger weights for opening the valves are cylindrical weights of cast iron, which are fastened upon the rods 4 and 15 of the working-gear, so that the central line of the weight corresponds with that of the rod. Each plunger is fitted into a short hollow cylinder, like that of a pump-barrel, which is fixed down in the condensing cistern, beneath the water. The lower end of each barrel is closed, but the bottom has a hole through the centre of it, which is covered with a leather clack-valve opening upwards. This clack
854 will admit the water freely into the barrel, as the plunger weight is raised upwards in it whilst the valves are closing; but when the plunger is left to fall suddenly by its own weight, in order to open the valves, the contained water must make its escape out of the barrel. The plunger does not fill the barrel very exactly, but a sufficient space is left to allow the water to squeeze out around the plunger on all sides as it descends; and so much resistance is thus opposed to the descent of the plunger, as will give it a suitable motion for opening the valves quickly, and yet without noise or concussion. This method allows the plunger weights to be made so heavy that they can have no chance
855 of sticking, or failing to open the valves; and yet they will act quietly, and without shaking or deranging the working gear."

They are also described in a public work entitled "Stuart's Anecdotes of the Steam Engine," volume II., at page 366; that description is as follows:—

(Page 366.) "The different construction of Watt's valves required a new arrangement of the hand-gear to move them. In the atmospheric engines the
856 weight or tumbling bob at the end of the levers, called the Y piece, was placed there, so that its fall should open the sliding-valve or the injection-cock with a jerk. It exerted no influence whatever in keeping the valves in their places, at least it was not introduced for that purpose. Watt also sometimes attached a weight to the spanners which opened or shut his valves. But it was necessary, in some arrangements of these parts, that they should be gradually shut

to prevent the injury that would be occasioned by a sudden jerking of the valves into their seats. This weight was therefore sometimes formed like a piston which rose and fell in a cylinder filled with water. The weights or plungers were made of cast iron, and cylindrical, each fitted into a hollow cylinder placed in the condensing cistern, and covered with water. The plunger is made somewhat less than the barrel, to allow a small space, by which, when it descends, the water may rise between it and the barrel. The lower end of each barrel is closed, except a small hole, which is covered by a leather valve opening inwards. When the plunger is drawn up, the water 857
from the cistern flows through this valve into the barrel; but when the plunger 858
descends the valve closes, and the water which is displaced rises between the plunger and the barrel, and the resistance which is thus occasioned to the descent of the weight prevents the concussion which would be produced by its uninterrupted fall, and at the same time affording a means of making the weight sufficiently heavy to open the valve."

They are more particularly described in these places, and allusion is made to the same mechanism elsewhere.

Q. Will you examine this model, (tin model of Watt's dash-pot,) and state whether or not it is a correct representation of the apparatus for arresting the descent of the valve, 859
as described in the books to which you have referred?

A. There are the same number of parts; but I do not think the weight fits the cylinder as closely as represented.

Q. Does not the text describe the proportions?

A. Not exactly, but only that there shall be just sufficient space between the plunger and the cylinder to permit the water to escape as rapidly as required.

Q. The drawing gives the proportions, I suppose?

A. I do not know. The drawing shows a space. I do not know that it is drawn on a scale. 860

Q. How do you get at the proportions, if neither the text nor the drawings give them?

A. By trying it—to make it descend just as rapidly as required.

Q. Does not the descent of the weight in *that* present a uniform resistance from the beginning to the end of the stroke?

A. It does, if it does not rise above the water, and if the bore of the chamber is parallel.

Q. Is it not intended to be parallel?

A. It is drawn so. 861

Q. And is it not intended to offer a uniform resistance?

A. I do not know what the intention is.

Q. Will you swear that, as described in the books and as represented in the plates, the liquid will not present a uniform resistance to the descent of that weight?

A. It certainly will not.

Q. Is there any secondary chamber in that apparatus, with an aperture through which the fluid escapes, which is gradually contracted by the descending weight?

A. Not that I know of. The drawing does not show it.

Hubbard P

862 On page 224, volume 1 of *Tredgold*, near the bottom, it says:

> "The descent of the weight which opens a valve is regulated by an ingenious method; it either descends into, or forces a piston into a vessel of water (see C, fig. 3, plate 9,) while the aperture by which the water escapes from under it may be increased or diminished at pleasure; the weight therefore acts with its full force to open the valve, but as soon as it begins to move it is retarded by the water, till it be finally stopped. During the ascent a valve opens inwardly, at the bottom of the vessel, and therefore the engine has not more than the weight to raise again."

863 Q. That, as described there, is for the purpose of opening the valve—is it not?

A. It is, in the drawing.

Q. Is it not, in the text?

A. It is. It is also described as closing it; but represented in the drawing as opening the valve.

Q. Where is it described as used for closing?

A. In *Farey*, at page 457, where the language is this, at the conclusion of the description of the valve-gear:

> "In the regular action of the working gear when moved by the chocks, the
> 864 valves are closed by the motion which those chocks give to the handles; and are opened again by the fall of the weights 4 and 15; nevertheless, when the engine is regulated by hand, that action may be reversed, if required; for the same effects may be produced by the contrary motions of the handles; and then the weights will tend to close the valves, instead of to open them. This property of Mr. Watt's working gear is very important; for although the four valves are moved with great certainty by the self-action of the engine, still they always remain under the control of the attendant, who can at any time give either two of the four valves, or all the four, an opposite position to
> 865 that which the self-action would give them."

Q. At any time during the operation, is the valve-stem in any manner latched, by a connection, with the plug-tree?

A. Not by any rigid mechanism.

Q. Is it connected in any way?

A. I should say there was a mechanical connection with the tappets upon the plug-rod.

Q. Is not the valve-rod and its connections connected with a latch having a lever?

866 A. What do you mean by the valve-rod?

Q. Is there not a rod by which the valve-stem is connected?

A. It is attached to a rocker-arm.

Q. Has not that rocker-arm a catch upon it?

A. Not that I know of.

Q. What holds the valve when in an open condition?

A. The mechanism further off.

Q. There is a tappet on the plug-tree which strikes this catch and liberates it, and permits the valve to be opened with a weight?

A. Yes.

Q. Then, on the return motion of the plug-tree, there is 867
another tappet, which disengages the other catch, to permit the valve to be opened?

A. Do you mean at the opposite end of the cylinder?

Q. Is not the valve lifted in *Tredgold* by a descending weight?

A. Yes.

Q. Is there not a catch which holds the mechanism, connected with it?

A. Yes, when the valve is closed.

Q. Then there is a tappet upon the plug-tree, which 868
strikes out that catch and permits the weight to open the valve?

A. Yes.

Q. Is there not another tappet upon that plug-tree, which operates upon the return motion?

A. Yes, to close it.

Q. Between the time of opening and closing, is there any connection between the plug-tree and the valve?

A. There is not.

Q. Then, between the time of closing and re-opening, is 869
there any connection between the plug-tree and valve-gear?

A. There is none.

Q. Do you find in the valve-gear to which you have referred in these books, an arrangement of mechanism in which the rod, or mechanism receiving motion from the eccentric, is connected with the valve, and continues in connection with it during the operation of opening the valve, and is then liberated from it, to permit the valve to close by a weight?

A. There is no eccentric employed. 870

Q. Is there any mechanical equivalent for an eccentric?

A. No.

Q. Is there any wrist-plate or connection to effect it?

A. Not exactly a wrist-plate; but there are rockers.

Q. In any of the valve-gear to which you have referred in these books, is there an arrangement of mechanism by which a rod of any sort, or of any form, receiving motion from the engine, is connected with the valve-stem in any manner, during the operation of opening the valve, and
then disconnected from it, to permit the valve to close by a 871
descending weight?

A. I think the question, in such general terms, would embrace the description in *Farey*; I think it would embrace the action of the plug-tree, where the weight was allowed to close the valve, instead of opening it;

Q. Have you not stated that in this description there is a plug-tree, with two tappets upon it?

A. Yes.

872 Q. And that one of those tappets strikes the catch, to regulate the valve in closing it, and that the other tappet, on its return motion, strikes the return catch, to close it?

A. Certainly.

Q. Is there any connection between that plug-tree and the valve-gear during the entire time of opening the valve?

A. Not with that arrangement.

Q. With any other arrangement?

A. The arangement described by *Farey*, where the valve is described as opening and closing by a direct motion of
873 the weight, would come within the scope of your question. I had more particular reference to this passage, which I will read:

> "Nevertheless, when the engine is regulated by hand, that action may be reversed, if required; for the same effects may be produced by the contrary motions of the handles, and then the weights will tend to close the valves, instead of to open them."

874 In that case the plug-rod would open the valve, and, if the action were reversed, it would trip it on the reverse motion, and allow the weight to close it.

Q. Then it is your judgment that the plug-tree, during that operation, is in connection with the mechanism of the valve, for the purpose of closing it?

A. It is, when moving the valve-gear; I should call it a mechanical connection.

Q. Is it by a mechanism having any analogy to a catch,
875 latch, or hook, taking hold of the valve-gear, or any portion of the valve-gear?

A. It seems to me to be analogous to the catches employed in each of these machines.

Q. Now, sir, if, during the operation in which the plug-tree is opening the valve, the plug-tree should, by some accident, reverse its motion and begin to descend, would the plug-tree be connected in any manner with the valve-gear?

A. I think it would; it would lower the valve back to
876 its seat.

Q. Is there not a tappet on there that strikes the lever, and forces it up in *that* way?

A. Yes.

Q. And that you call analogous to a catch or latch?

A. No, sir; I did not say so.

Q. Has it any analogy whatever?

A. Yes, because it gives motion to it; it has some analogy because it gives motion to it, and passes by and leaves it.

On being further *re-examined* by the counsel for the de-

fendants, the witness, WILLIAM C. HIBBARD, testified as 877
follows :

Q. Does the tin model produced by the plaintiffs represent the dash-pot, as constructed by Watt?

A. Yes, except, as I stated, I think the plunger is too small; there is too great a space between the plunger and the inside of the dash-pot; it requires something more than that to be complete; it wants to be set in a cistern of water.

Q. Does it represent accurately the connection between the inner reservoir and the outer reservoir?

A. There is a valve here of a little different form, but I 878
do not think there is any material difference.

Q. Is this contrivance of Watt described in any other book except *Tredgold?*

A. It is described in almost all the books that treat on the steam-engine.

Q. Will you read the description of it?

(The witness read from page 224, volume 1, of *Tredgold*, as follows:

A weight *w*, sufficient to overcome the friction and open the valve, acts by
a short arm *a*, on the axis which requires to be turned to move the valve; the 879
weight is kept suspended by a spring catch *b* while the valve is closed, and when the catch is disengaged by the handle *c* being moved by the tappet *d*, the valve opens. If the valve be large it requires a considerable weight *w* to open it against the pressure of the steam; and in that case either the valve described in article 442, or Watt's mode of relieving the pressure, may be adopted. It will naturally be inquired why weights are used to open the valves, instead of using the direct power of the beam? The only reason assigned for so doing is, that a weight opens a valve more rapidly, and the loss 880
by closing them slowly was not quite so readily detected; though the absolute loss is about the same, and the practice is becoming more common to open them by direct action. The descent of the weight which opens a valve is regulated by an ingenious method: it either descends into, or forces a piston into a vessel of water, (see C, fig. 3, plate 9,) while the aperture by which the water escapes from under it may be increased or diminished at pleasure; the weight, therefore, acts with its full force to open the valve; but as soon as it begins to move, it is retarded by the water, till it be finally stopped. During the ascent, a valve opens inwardly at the bottom of the vessel, and 881
therefore the engine has not more than the weight to raise again.)

Q. Where do you understand that aperture to be placed, there referred to?

A. The drawing does not show, and the text does not state, its particular position in the dash-pot in which the weight descends; but from its structure in the drawing it would be on its side.

Q. Where is the valve situated as there described as opening inwardly?

A. Near the bottom—on the side.

882 Q. Where does the language of the text place the valve which opens inwardly?

A. *Tredgold* does not describe it, but it is described in *Farey*.

Q. Turn to *Farey*, and look at the description there?

A. The description of "plunging weights," as they were called, for opening valves, is found on page 530, and the language is this:

> "Plunger weights for opening the valves are cylindrical weights of cast
> 883 iron, which are fastened upon the rods 4 and 15 of the working-gear, so that the central line of the weight corresponds with that of the rod. Each plunger is fitted into a short hollow cylinder, like that of a pump-barrel, which is fixed down in the condensing cistern, beneath the water. The lower end of each barrel is closed, but the bottom has a hole through the centre of it, which is covered with a leather clack-valve, which opens upwards. This clack will admit the water freely into the barrel, as the plunger weight is raised upwards in it, whilst the valves are closing; but when the plunger is left to fall suddenly by its own weight, in order to open the valves, the contained water must make its escape out of the barrel. The plunger does not fill the barrel
> 884 very exactly, but a sufficient space is left to allow the water to squeeze out around the plunger on all sides, as it descends; and so much resistance is thus opposed to the descent of the plunger, as will give it a suitable motion for opening the valves quickly, and yet without noise or concussion. This method allows the plunger-weights to be made so heavy that they can have no chance of sticking, or failing to open the valves; and yet they will act quietly, and without shaking or deranging the working-gear."

There is also a short allusion to it at page 366, vol. 2, of *Stuart's Anecdotes of the Steam-Engine:*

> 885 "Watt also sometimes attached a weight to the spanners which opened or shut his valves. But it was necessary in some arrangements of these parts, that they should be gradually shut, to prevent the injury that would be occasioned by a sudden jerking of the valves into their seats. This weight was, therefore, sometimes formed like a piston, which rose and fell in a cylinder filled with water. The weights, or plungers, were made of cast iron, and cylindrical, each fitted into a hollow cylinder, placed in the condensing cistern, and covered with water; the plunger is made somewhat less than the barrel, to allow a small space, by which, when it descends, the water may rise between it and the barrel; the lower end of each barrel is closed, except a small
> 886 hole, which is covered by a leather valve, opening inwards. When the plunger is drawn up, the water from the cistern flows through this valve into the barrel; but when the plunger descends, the valve closes, and the water which is displaced rises between the plunger and the barrel, and the resistance which is thus occasioned to the descent of the weight prevents the concussion which would be produced by its uninterrupted fall, and at the same time affording a means of making the weight sufficiently heavy to open the valve."

Q. Do you find any description of the valve-gearing with
887 which this weight is connected, in these books?

A. It is at the places referred to.

Q. When this barrel is fastened to the bottom of the cistern, where must the aperture be for the ingress of the water?

A. I should think it would have to be from the side.

Q. And where would be the one which lets the water out? 888

A. That would have to be also upon the side, if it were fastened closely to the bottom of the cistern, as shown in the drawing.

Q. Would the weight move more rapidly at the commencement of its motion than towards the close of its motion?

A. I do not know that it would; I think it would commence, provided it were filled with water, and the sides of the barrel were parallel, from a state of rest, accelerate until it got to a constant motion, and then descend gradually.

Q. Suppose the tube containing the water to be partially filled with water, and the weight to be drawn out, or al- 889
most entirely out, what would be the action of it in its descent?

A. It would descend more rapidly at the first part of its motion than at the latter part.

Q. Suppose the weight to be made of a length equal to the distance of the whole movement of it, and that it be drawn nearly or quite to the surface of the water, leaving the barrel immersed, what would then be the action of it in its descent?

A. It would accelerate until the friction became equal
to its gravity, and then it would retard; because the escape 890
of the water would be retarded as the aperture for the escape became longer, from the plunger entering the barrel further.

Q. Would it or not move freely?

A. Yes; but owing to the increased friction of the water in escaping, it would retard its motion.

Q. Where would it begin to be retarded?

A. I should think somewhere about half its motion; I never have tried any experiment to determine the point.

Q. Suppose this cylinder to be raised from the bottom of the cistern, and constructed as described in *Farey*, with a
valve in the bottom, and as also described in *Tredgold*, 891
with an aperture in the side, which would be covered by the weight in its descent, what would then be the operation?

A. If the weight passed the hole, it would offer an increased retardation to it, to some extent; but the plunger being loose around it, it would have less effect.

Q. In that case, could you or not make a weight so as nearly to fit the cistern in which it moves?

A. You could, if so constructed as to make an aperture to let the water out.

Q. How would the operation of this weight and cylinder,
892 so constructed, compare with that in the defendants' machine?

A. It would be quite similar, except in the employment of a different kind of fluid to work with.

Q. Would there be any other difference?

A. I do not know that there would be. There is a difference that is due to the difference between the fluids used. Where one is used with air, it is capable of being applied to purposes to which, if it were used with water, it could not be.

Q. Which would be the most advantageous, water or air, to be used as I have described?

893 A. It would depend upon the purpose to which it was applied. If accurate adjustment were wanted, water would be the best; but if that were not a consideration, but simply to bring the weight to a state of rest, without concussion, I should like the air best.

Q. I wish to prove this diagram. Will you compare this diagram with the one in *Tredgold*?

A. It appears to me to be substantially correct, with the exception that the water-line is not high enough.

Q. Will you examine this model (of Watt's apparatus) and see if it is the apparatus described in *Tredgold* and the others?

894 A. Substantially it is.

Q. Are the connections in the model accurate?

A. I should think they were.

Q. Will you explain upon the model how the valve is opened and closed, and how the plug-tree acts upon the valve?

[Witness explained upon the model.]

Q. What is the use of the weight in that model?

A. To draw the valve open suddenly.

Q. What is the object of the reservoir into which the weight falls?

A. To check the descent of the weight, and prevent it
895 from making a concussion.

Q. When the valves were arranged as described in *Stuart* so that the valves would be suddenly jerked into their seats, what was then the object of the weight and reservoir?

A. To prevent the valves from making a concussion upon their seats, as that would be the surface by which their movement would be finally arrested.

Q. Was it not to prevent the slamming of the valves?

A. Yes, as I understand it from *Stuart*.

Q. What portion of that model represents the spring-catch described in *Farey?*

A. It is this balance-lever, with a spring acting upon it, which effects an engagement with the catch. 896

Q. During what portion of the stroke is the plug-tree in connection with the valve-gear?

A. It depends upon how the valve is arranged—whether to work a full or half-stroke.

Q. Taking any other condition?

A. And also whether the weight opens or closes the valve. It would be modified to suit these conditions.

Q. Could or not that be adjusted so as to admit steam for a greater or less portion of the stroke? 897

A. Yes; gear of that description is shown in plate 24 of *Farey;* rod fig. 13 represents the rod by which the tappet is adjusted to its proper position.

On being further *cross-examined*, the witness, William C. Hibbard, testified as follows:

Q. Is the representation on *that* model, of the cylinder and plunger, to arrest the descending weight, a correct representation from the book?

A. No; it only represents its position and external structure. There is no valve shown upon it. 898

Q. Is there anything in the text, or any representation in the plates, which indicates that the weight or any portion of the weight is to be out of the water during any portion of the operation?

A. I do not recollect that there is.

Q. In *Farey* and in *Stuart*, do you find any other escape for the water during the descent of the plunger, than between the plunger and cylinder?

A. There is none described, if I recollect rightly. 899

Q. In the description of *Tredgold*, and in the plate, is there any aperture at the side?

A. There is not any represented.

Q. Except the one which has the valve opening inward?

A. That is the only one shown in the drawing.

Q. Do you find in the text, or in the drawing, any of the hypotheses that have been put to you in the questions, in your examination-in-chief?

A. Refer more particularly.

Q. As to the dash-pot having two apertures at the side 900 —one of which is to be partly closed by the descending of the plunger?

A. I do not find any such description.

Q. Do you find any description intimating that the weight at the time of starting is to be nearly out of the water, and to be checked by becoming gradually immersed?

A. I do not.

901 Q. Does the dash-pot, as described in either of those books, operate substantially like the dash-pot used by the defendants—affording a free descent of the weight during the greater part of its downward motion, and a sudden checking at the end of its downward motion?

A. It is not described as so operating.

Q. Does the valve-gear represented in that model, or as described in either of the books to which you have referred, operate the valve by a combination and arrangement of mechanism, substantially like that used by the defendants?

A. I do not think it does.

902 On being *cross-examined* by *Mr. Keller*, the witness, Mertoun C. Bryant, testified as follows:

Q. In the defendants' engine at Youngs & Cutter's, and in the brass rolling mill, is not *this* wrist-plate, relatively to *these* other parts, considerably lower down, so that *this* arm, instead of inclining upwards, inclines downwards?

A. I think so.

Q. Now, I will ask you whether at Youngs & Cutter's there is any period of the operation of the engine in which the lifter-rods, or hook-rods, as you call them, make an inclination lower down towards the catch?

A. I think they do.

903 Q. At the time that the wrist-plate is at the highest point, do not the rods incline in an opposite direction to what they do in this model?

A. I do not think they do.

Q. Then you think that in this particular the model is correct?

A. I think so.

Q. In the defendants' engine is not the connecting rod to which the weight is suspended made with an adjustable nut?

A. It is made similar to that shown.

Q. I understood you to testify, yesterday, that Sickels' invention seems to have been to make an improvement on
904 the valve-gear then in use for working puppet-valves, Where did you derive this impression?

A. From information I received in reading books on the state of the arts at the time, and in his own specification, which, on the face of it, does not go any farther.

Q. Did you derive the impression, from reading Sickels' specification, that he intended to limit his improvement to the kind of valve-gear then used for working puppet-valves?

A. That is all the apparatus that he describes in his specification.

Q. I want to know where you obtained the impression

that he meant to limit his improvement to that kind of valve- 905
gear?

A. From the knowledge that came to me of the state of the arts at that time, it seemed plain that detachable valve-gear for shifting and opening the valves was not his invention, because I found it described in other places. Sickels' description takes up that, as it were, and adds an adaptation to it for detaching or tripping the valve. That seems to be the whole range and intent to be found in the description.

Q. Now, sir, from your *extensive* knowledge of the state
of the steam-engine, will you tell me where you find the 906
description of a valve-gear in which the lifter, deriving motion from any portion of the engine, is latched to the valve-stem for the purpose of opening the valve, and then that connection broken, to permit the valve to be closed by a weight, while the valve-gear continues its motion, and returns to re-engage the catch?

A. I do not know that there is any description that embodies all those combinations.

Q. Do you not find that combination in the defendants'?

A. No. In the first place, the defendants have no valve-
stem, and I do not think they have a lifter. It lacks these 907
elements in the terms that you speak of it. I do not know that I can speak of anything else, but very likely there may be.

Q. Is there not in the defendants' a rod which receives motion ultimately from the eccentric, and which is alternately connected with and disconnected from an arm connecting with the rocking-shaft of the valve, by means of a spring-latch, that the valve may be liberated from that rod, to be closed by a weight, while the rod continues its motion
and returns to be re-engaged? 908

A. All those combinations exist, but the ultimate point of starting—the ultimate motion—is back of the eccentric.

Q. Is not the motion ultimately, so far as regards the valve-gear, derived f. om the eccentric?

A. No, it is not.

Q. Where is it derived from?

A. Part of it is derived from the eccentric, part from the connection with the regulator, and part from the weights.

Q. Will you tell me what motion of the valve-gear is
derived from the governor? 909

A. It is the motion which unhooks, limited and controlled, in that way derived from the governor.

Q. I want you to point out to me how motion is communicated to the hook-rod or lifter by the governor?

A. I said that the motion was derived from the governor. I did not say it was communicated by the governor.

Bryant X

910 Q. Will you show to the jury where it is derived from the governor?

A. The position of *this* stop controls the movement of *this* hook-rod (explaining on the model of the defendants' engine.) The position of *this* stop is controlled from the governor. Therefore I say the action of the hook-rod is derived partially from the governor.

Q. Now, sir, when the engine is moving at uniform speed, does the governor move the stop in any way?

A. It would not, at uniform speed.

911 Q. Does the governor do anything more than determine the position of the stops against which the hook-rods work?

A. That is the direct action of the governor, to fix the position.

Q. Is there any indirect action beyond that?

A. A great deal. The governor controls the engine throughout.

Q. Is not the valve-stem the stem or rod which passes from the valve through a stuffing-box, to form a connection

912 with the mechanism which operates the valve?

A. The *valve-stem* is a technical term. The rod which runs through the stuffing-box is not necessarily a valve-stem. I find that *this* rod (referring to the model of Watt's invention) is described as being a valve-stem, but it is not the connection which extends out of the steam-chest; for that reason, I suppose that connection is not a valve-stem.

Q. Does not *this* rock-shaft in the defendants' take hold of and communicate motion to the valve without the valve-

913 chest?

A. It does.

Q. Explain on the model how it does communicate motion to the valve. (Witness illustrated.)

Q. Is not *that* rock-shaft connected with the valve for the purpose of communicating motion to the valve in the steam-chest?

A. Yes.

Q. Is there not upon that shaft an arm?

A. Yes.

Q. Through which motion is communicated to the rock-

914 shaft, and ultimately to the valve?

A. Yes.

Q. The object of that shaft being to communicate motion to the valve within the steam-chest, and the object of the stem in Sickels' model being to communicate motion to the valve within the valve-chest, are they not, to that extent, equivalents for each other?

A. If you limit the operation to be that thing, and make the description of a valve-stem to be that thing which

communicates motion from the outside of the steam-chest 915
to the inside of the steam-chest, then they are valve-stems
—then they are equivalents.

Q. So far as regards communicating motion to the valve-stem to open and close the valve, is not *this* hook-rod an equivalent for the lifter-rod in Sickels'?

A. You state one thing which I do not consider to exist. You state the connection of the valve-stem, and I do not consider that there is any valve-stem in the defendants'.

Q. Is not the hook-rod in the defendants' machine, for
the purpose of communicating motion to what you have 916
described as the equivalent for the valve-stem moving the valve, an equivalent for the lifting-rod described in Sickels' patent?

Equivalents

A. This matter of equivalents I consider as rather peculiar, and can only exist, as I think, either with regard to two things acting exactly in the same manner or two things acting substantially in the same manner. A dollar may be an equivalent for a bushel of corn in the market, but it is not an equivalent if a man has to eat it. So the de-
taching of the hook in the defendants' is an equivalent for 917
the detaching of the latches in the plaintiffs' as a means of communicating power to the valve. So far they are equivalent, and no farther.

Q. Do they not, in other words, perform the same mechanical office or function of opening the valve, and permitting the valve to be liberated, that it may be closed by a falling weight?

A. There is no doubt but that the opening of the valves in the Corliss engine is produced by the engagement of
the hooks, and the valve is drawn over its port by the fall- 918
ing of the weight. There is no doubt but that in Sickels' the lifting of the valve is performed by the spring engaging upon the valve-stem, and the falling of the valve is produced by the weight of itself and the pressure of the steam. So far, the hooks are like the springs and latches.

Q. Now, sir, in mechanics generally, in the combination of machinery, where a particular office is to be performed by a described instrument, and any other will perform the same office in connection with the others, and performs
other offices in addition—to the extent that it performs the 919
same office, is it not an equivalent for the one for which it is substituted?

A. Yes, so far as it goes.

Q. Now, sir, in machinery, are there not a great many forms of latches for effecting a connection of one part of a piece of mechanism with another, some working with springs and some with weights?

A. There are.

920 Q. So far as regards the mere office of connecting two pieces of mechanism, so that they can be disconnected, is the substitution of any one of these for another the substitution of an equivalent?

A. That would depend upon the objects to be effected.

Q. Now, sir, as a mechanician, do you or not know that, without the exercise of invention, you could take the mechanism here represented in Sickels' model, and perform precisely the operation that his performs, for the purpose of liberating the valve-stem within any desired portion of the
921 half-stroke, by substituting a great variety of forms of catches for the kind of catches which he here describes?

A. I do not think that any one knows that the substitution of any other kind of latch would accomplish precisely the same object as that accomplishes.

Equivalents

Q. Can you imagine the substitution of any other kind of latch that would produce a different result from this?

A. I could imagine that another kind of latch would produce a different result.

Q. What kind of difference?

922 A. That would depend upon what kind of latch was used.

Q. Suppose we substitute a weighted lever-latch for a spring-catch, would that vary the result produced?

A. I suppose a weighted lever-latch might be adapted, in some way or other, to liberate the stem from the lifter.

Q. And permit it to re-engage?

A. One form might liberate it and permit it to re-engage, and another might not.

Q. Can you conceive one that might not?

923 A. I can conceive it.

Q. Could you, without invention, substitute a weighted lever-catch for a spring-latch?

A. I do not think I could.

Q. If you could, would that destroy the substantial identity of Sickels' invention?

A. I do not think anything I could do would destroy the identity of his combination.

Q. What experience have you had in planning the con-
924 struction of or working steam-engines?

A. Not very much; I may say none in the construction of steam-engines.

Q. Have you ever constructed a steam-engine?

A. Never.

Q. For how long a time, if any, have you been engaged in working steam-engines?

A. I never worked a steam-engine regularly.

Q. How long have you had steam-engines under your control in any way?

A. For two or three years; I have one under my control now, and that has been so for four years. 925
Q. In what establishment?
A. The gas-works, at Lowell.
Q. What kind of an engine is it?
A. It has an upright cylinder.
Q. Have you any other control of it than simply being the superintendent of the gas-works?
A. No, sir.
Q. I will ask you whether the arrangement of hook-rods and wrist-plate represented in the defendants' model, can be applied to work puppet-valves? 926
A. I do not know.
Q. Would that arrangement effect it? (producing a skeleton model.)
A. Explain what you mean.
Q. Do you not understand that model?
A. No.
(*Mr. Keller* explained the model to the witness.)
Q. The question is, whether that does not represent the wrist-plate and hook-rod of the defendants' arrangement, applied to working puppet-valves and tripping them?
A. It may effect something of that kind, but it does not represent the action of the defendants' hook-rod; it does not act in the same way; it rests upon the stop for a longer time than in the defendants'. 927
Q. Will you swear that it is substantially different for that reason?
A. Yes; I conceive it to be so.
Q. Will you swear that *this* inclination of the hook to the line of *that* stem is not as great as the inclination in the engine at Youngs & Cutter's?
A. I will not make any statement, one way or the other. 928
Q. Do you think that by the hook-rod and the wrist-plate in the defendants' model, you would be able to work puppet-valves by such a connection as is represented here—*this* representing the stem of the puppet-valve, and *this* the rocking motion of the defendants' valves?
A. I have no doubt that puppet-valves might be connected to a thing like this, and let to trip.
Q. Is not that all that is necessary to work the cut-off?
A. There are other things. 929
Q. What other things?
A. It must be lifted to a certain position.
Q. Will not the sliding stop determine that position?
A. That depends upon how the parts are arranged.
Q. Can you arrange them as in the defendants', and regulate them in the same way?
A. Very likely you may.

930 Q. Can not you imagine an arm attached to the rock-shaft of the defendants' valve, and jointed to the stem of a puppet-valve, so as to lift the puppet-valve, and when the latch is liberated to permit the valve to drop?

A. Such a thing might be done; I cannot say.

Q. Did not *that* (representation of Watt's invention) work puppet-valves?

A. No doubt but what it did.

Q. Did you ever see it work?

A. No, sir.

Q. Then how can you judge whether it did or not?

931 A. From the description in the books.

Q. Is it merely from the judgment of the author, or from your own that you determine it?

A. I take the statements of men acquainted with these matters to be facts, unless something is shown to the contrary.

Q. Now, sir, assuming *this* rod to represent the lifter, and *this* the stem of the puppet-valve, and *here* a weighted lever-catch, would not that lift the valve and trip it and permit it to descend?

932 A. I think it would.

Q. Would the substitution of that weighted lever-catch for the spring-lever-catch in the defendants', change the substantial identity of the defendants'?

A. It would be very likely to.

Q. Would it or not?

A. I cannot say.

Q. Does the catch in Sickels' arrangement perform any other office than that of hooking and unhooking?

A. Yes; it performs the office of going around.

933 Q. Is there any other office that it performs, so far as regards cutting off anywhere within half-stroke?

A. I do not think there is any other.

Q. Then, would not this weighted lever-catch be an equivalent, so far as that goes?

A. In disengaging the weight, I would consider them substantially the same.

Q. I want to know whether it would be substantially the
same combination as that found in Sickels', so far as the ad-
934 justment of the cut-off within half-stroke goes?

A. I do not think it would be the same combination.

Q. Would the substitution of one for the other require the exercise of invention?

A. I think it would, if it had never been known before.

Q. Would it destroy the substantial identity of the original combination?

A. I do not know that it would have any effect upon the original combination.

Q. You stated, that one of the essential properties of Sickels', was its capacity to cut off beyond half-stroke; if you fill up the space between the two wedges in the adjustable sliding piece, would it then be capable of cutting off beyond half-stroke? 935

A. If that is all the alteration you made, it would not?

Q. Would that destroy the substantial identity of Sickels' invention?

A. I do not think that any change you made would destroy the substantial identity of an invention.

Q. With that alteration, would it continue to be substantially the same? 936

A. So far as it went, it would.

Q. Then, why did you testify yesterday that the capacity to reverse was an essential part of the combination?

A. That is part of the combination; without that, you have not the whole of it.

Q. If you had this apparatus just as it is represented in Sickels' model, on a steam-engine, and you never reversed the adjustable piece, but used it entirely to cut off within half-stroke, do you think you would be using Sickels' invention, or some other invention? 937

A. I think you would be using Sickels' invention.

Q. Now, sir, you have stated that the defendants' cannot cut off beyond half-stroke; suppose, by an addition to it, it could cut off beyond half-stroke, would that make the arrangement substantially different?

A. A combination may be said to consist of a number of parts; if you add one, it does not alter the combination; if you take one from them, it does.

Q. Would that addition destroy the identity of the defendants' combination?

A. No, it would not. 938

Q. If you have a throttle-valve applied to a steam-engine, to be adjusted by hand, to regulate the amount of steam to be admitted to the steam-valve, and you adapt the governor to it, so as to render it automatic, does that destroy the original combination of the throttle-valve with the engine, or is it an improvement added to it?

A. I do not think it would destroy the combination; it would be an improvement added to it. 939

Q. Is this arrangement of cut-off, which comes from the De Laine Mills, substantially the same arrangement and combination as is described in Sickels' patent?

A. So far as it goes, it is; it has not the combination to effect the cut off beyond half-stroke.

Q. You stated that there were indications of considerable wear upon this rod; do you know whether it was produced by the actual working of the engine?

940 A. I do not know anything about it, except that it appears to be worn.

Q. Judging from the size of these valves, what would you think the power of the engine to which they belonged?

A. I should not be able to judge.

Q. Is there any more power required to disengage the valve than what is necessary to overcome the tension of the spring and the friction due to the weight of the valve resting upon the catch?

A. Yes, there is also friction between the catch and the
941 lifter, which has to be overcome.

Q. Is it not a rule in mechanics, that friction is as the weight, and not as the surfaces in contact?

A. The friction on a surface that is not sufficiently small to abrade or tear, is measured by the weight and not by the surface.

Q. Now, sir, as a question in steam-engines, is not the weight that you see here used for closing the valves in the defendants' engine greater than the amount of weight to
942 close the valves in *that* connection resting upon a spring?

A. A pair of steelyards would tell you better than I.

Q. As a general rule in steam-engines, does it not require less power to operate the balanced puppet-valve than it does to work the slide-valve for a given area of steam-port?

A. It would depend upon the construction of both.

Q. Assuming that it does require less power to open balanced puppet-valves than it does to open the slide-valves, would not as much power be required to disengage the catch on the defendants' as on the plaintiffs' taking in view
943 the weight on both?

A. I cannot answer, without sufficient grounds to base my statement upon.

Q. Upon what foundation, then, did you testify that it required more power to unlatch Sickels' valve-stem than it did to unlatch the defendants'?

A. The force acting upon the wedges was in my mind at the time.

Q. That wedge is simply to disengage the latch, is it not?

944 A. Yes; and it has to keep it in engagement part of the time.

Q. At the time of unlatching?

A. No.

Q. Did not my question relate to the operation of unlatching?

A. Then I misunderstood it. The wedges act upon the spring, which tends to separate the ends of the spring between the valve-stem and the wedges, and requires a certain amount of tension, and as it goes on that tension in-

creases. When the tension is great enough, the springs will be thrown out of the notch in the valve-stem. 945

Q. Suppose it is rigid, like that in this (De Laine) engine, will the wedge, acting upon that, exert any greater mechanical force than is required to be exerted upon the defendants', to disengage the catch?

A. If the two surfaces are alike, move at the same velocity, and have the same weight, there would be no difference.

Q. Now, sir, with reference to the governor, you have stated that the defendants' combination and arrangement was substantially different from Sickels', among other rea- 946
sons, because, in the defendants', the adjustability of the cut-off is determined by the governor—I want to know whether that is an improvement added to the original combination, or whether it destroys the original combination?

A. If it previously had a combination without that rod being connected with the governor, it is certainly an addition. It does not destroy what was there before.

Q. Suppose you take Sickels' arrangement, and throw away the set screw of the adjustable sliding piece, by which it is fastened in any particular position required, and sub- 947
stitute a slide with an inclined groove, having an inclination corresponding to the inclination of the wedges on the sliding rod of the defendants' arrangement, and you connect that slide with the governor, to be operated by the governor,—would Sickels' arrangement then be regulated by the governor in determining the point of cut-off?—Would that destroy Sickels' original combination?

A. It would destroy the combination as he has described it—taking away that set screw.

Q. Throwing aside his description, and taking this 948
model,—would the alteration that I have pointed out destroy the substantial identity of the combination represented in this model?

A. It would certainly. It would make a thing that would not operate.

Q. Would it not regulate by the governor, with the substitution that I have made for the screw?

A. I do not think it would work effectively, because I do not think it is adapted to the governor. The governor must 949
have a free chance to act. When these springs are in contact with the wedges, then the governor is confined by them, and as soon as released would be likely to run by its proper limit.

Q. When these hook-rods are in contact with the adjustable stop in the defendants,' is the governor free to open then?

A. No.

950 Q. Then the moment the hook-rods are disengaged, and the governor asserts freedom of action, would it not then take its proper position to indicate the speed of the engine? I want to know first, whether the governor is free to move when the hook-rods are being disengaged; and, secondly, whether the governor is not free to move when the catches have been disengaged?

A. Yes.

Q. Now, I want to know whether, in the plaintiffs', under the arrangement in connection with the governor, the go-
951 vernor will not be free to operate after the catches have been disengaged, and whether it will be checked in its operation for any longer time than is necessary to disengage the catches?

A. In that arrangement, you cannot disengage them so quickly.

Q. During what portion of the time required for one stroke of the engine, in the defendants', are the stops in contact with the hook-rod?

A. I should not think more than one-twentieth.

Q. Will you swear that it is as little as one-twentieth?

952 A. No.

Q. What proportion of the stroke would it require in Sickels' engine to disengage the latch with this wedge?

A. I would think, from the appearance there, that the latch was in connection with the wedges three-quarters of an inch, and that the valves were raised about three inches; that would make about one-quarter of the time, within the half-stroke—one-eighth of the entire stroke.

Q. Now, just look at this model and see if you have not under-estimated the time required to effect the cut-off in
953 the defendants' machine—is it as little as one-twentieth?

A. I cannot say. Just as quick as the stop comes in contact with the wedge, the engagement seems to take place.

Q. Does not the length of time required to disengage the catch depend upon the leverage of the catch upon each side of the fulcrum?

A. If the angular velocity of the lever is the same, it would be unlatched in the same time.

Q. Now, sir, as to the dash-pot. You have stated, among other things, that the defendants' engine can work by a
954 loose connection between the weight and the arm of the valve and the rock-shaft. How long did you see it working in that way?

A. I should say ten or fifteen minutes.

Q. Do you know whether the same thing can be done in Sickels'?

A. I do not know whether it could or not.

Q. Did you not swear yesterday that it could not?

A. Very likely I did. 955

Q. I will ask you now for a revision. Can the plunger of the dash-pot be connected with the puppet-valve by means of a loose connection, and prevent the slamming of the valve?

A. If the question is whether the dash-pot can be connected with the valves, to prevent their slamming, I suppose there might be some way.

Q. Now, taking this arrangement, (the De Laine engine,) suppose you connect a chain from *there* to the stem near the valve, when the lifter with its catch lifts this, will it 956
not lift the dasher in the dash-pot above, and at the same time lift the valve, and, when the valve descends, will it not form a tight connection between the valve and the dash-pot, so that the dasher will arrest the descent of the valve as effectually as with a rigid connection?

A. No doubt you can make a connection in that way.

Q. You stated yesterday, and gave us as an illustration of the sensitiveness of the lever, the action of piano-keys. Did you, at the time of speaking of this delicate instrument for ladies' fingers, imagine a weight of the size of *that* (defendants' plunger) hanging upon the end of the piano- 957
keys?

A. No.

Q. Do you think Hercules would have had strength enough in his fingers to play a piano with such weights?

A. If he were as strong as they say he was, I suppose he might.

Q. Now, sir, while we are upon these delicate weights—you spoke of an arrangement or experiment that you saw tried, with carpets and leather put at the bottom of that pot, instead of the air. Do you think that that would be practical for the continued action of an engine? 958

A. Yes.

Q. Do not these weights thump 96 times per minute, or twice for each revolution?

A. Yes, twice each revolution.

Q. (Raising the weight and allowing it to fall on some carpeting,) do you think *that* would do for a practical working engine?

A. Yes, sir. Supposing that the thumping operation is not carried to any other part of the engine, it would not 959
affect the working of the engine.

Q. How much carpet would be consumed in the course of a year with that sort of thumping?

A. I never entered into the calculation.

Q. How long would it take leather to present as great a resistance as solid iron, when under the operation of this thumping weight?

960 A. Probably something over a thousand years. I do not know how much more.

Q. That you will testify to, under your oath?

A. Yes. I do not think it would ever become so hard as iron.

Q. Let us come back to the dash-pot used by the defendants in the actual working of the engine. Do you not find in that an aperture which, by the descent of the weight, is gradually contracted to check the escape of the fluid?

A. Yes.

Q. Is it not the same in Sickels'?

961 A. The aperture for the discharge is gradually contracted in Sickels'.

Q. In both do you not find that the weight descends through the greater portion of its motion without serious obstruction from the fluid employed, and that, towards the end, by the gradual contraction of the aperture through which the fluid passes, that fluid presents a rapid check or resistance to the downward motion?

A. I do not think that, in the defendants', is due to the escape of the fluid. The fluid in the defendants' does not
962 escape freely. It is governed or controlled by a set screw, which regulates the descent of the weight.

Q. Now, putting that screw out of the way, answer my question?

A. When it is taken away, still there is resistance there which would check the weight in falling, more than it would in open space.

Q. Is there not water in the other to check it, more than it would be in open space?

A. Yes.

Q. Cannot you answer me now, whether in both the weight does not descend rapidly by the free discharge or escape of fluid, and is then checked at the end of its downward motion, by confining the fluid gradually by the contraction of the aperture?

963 A. Yes, as you have described it, I think the same action takes place in both.

Q. If you were to take the dash-pot just exactly as it is described in Sickels' patent, and substitute it for the air-dash-pot in the defendants' engine, would it not answer just as well to govern the closing of the valve and prevent the slamming of the weight, as the air-dash-pot used by the defendants?

A. I think it would. I think a great many other things would answer just the same.

Q. In that case, would that part of Sickels' invention be substantially used by the defendants?

A. If it were put there, it would. I do not think it would be used for substantially the same purpose. 964
Q. Would it not regulate the closing of the valve?
A. No.
Q. What would regulate the closing of the valve there?
A. The falling of the weight.
Q. What is it that stops the valve?
A. It is not stopped until after it is closed.
Q. As long as it is in connection with that weight, what is it that stops the valve?
A. The friction of the valve-surface. 965
Q. Suppose the weight to be there for the legitimate purpose of closing the valve, and you take away all support from under that weight, what would regulate the stopping of the valve?
A. As long as the weight is attached to the valve, it has sufficient force to move it. As long as the weight is in motion, the valve will follow it; but as quickly as the effect of the weight is taken off, the valve will stop.
Q. Does not that which regulates the stopping of the weight regulate the stopping of the valve?
A. As it is arranged, the weight falls to a certain position, and carries the valve with it. 966
Q. Answer my question. Does not the stopping of the weight regulate the stopping of the valve, in the connections found in the defendants' engine?
A. Yes, I think it does.
Q. Now, a few words with reference to the wire-drawing of steam. You stated that in the working of the defendants' engine, you found, immediately after the opening of the valve, if I understood you correctly, a pressure on the cylinder, indicating 2 lbs. less than the steam in the boiler. Am I correct? 967
A. Within 2 lbs.
Q. Did it reach 2 lbs.?
A. I do not think it did.
Q. Was it far from it?
A. It varied at different times.
Q. Was it ever as much as 2 lbs.?
A. I do not think it was.
Q. How far from two pounds was the ultimate? 968
A. I did not remark the figures. I remember I took it in my mind, and it was less than two lbs.
Q. By what means did you test it?
A. By pressure guages.
Q. Whose pressure guage?
A. I do not know whose it was.
Q. Are you in the habit of testing pressures without knowing the instruments?

969 A. I took the same instrument, and applied it in two different places.

[The witness here said that he wished to correct his former answer. It was not the same instrument which they used, to test the pressure of steam in different parts of the engine, but two different guages were used, and compared with each other to test their accuracy.]

Q. Have you ever tested the relative pressure of the steam in the cylinder immediately on the starting of the piston, with a puppet-valve engine, and the pressure in the
970 boiler?

A. No.

Q. Can you testify that Corliss' engine indicates less wire-drawing than would be produced by a puppet-valve engine?

A. No, I cannot testify as to my own knowledge.

Q. Is it not a fact that the puppet-valve, for a given amount of motion and a given area of steam-port, will present a larger area of opening than either the rotating or sliding-valve?

971 A. It would depend upon how the sliding or rotating valve was made—it would depend upon the length of its opening.

Q. Assume *this* valve (presenting a model) to be the same area as *that* aperture, and the valve to move one-eighth of an inch over the edge of *that* port, will it present as large an area for the passage of steam as if it be lifted up from the surface one-eighth?

A. No.

Q. Then, sir, in view of that, explain how the slide-valve,
972 in any form, presents as large an area of opening as the puppet-valve for a given amount of motion?

A. It all depends upon the length of the opening—the length in proportion to the motion. In *that*, if *that* were half as long as it is now, the same amount of motion would open half as much space; and, if ten times as long, the same amount of motion would open ten times as much space. When the puppet-valve is lifted from its seat, the circumference of the valve is a certain length. If you raise it half an inch, then you make an opening into it equal to
973 the area of an eighth of an inch by its circumference. If *this* (in the model) were as long as the circumference of the puppet-valve, you move it an eighth of an inch.

Q. I am assuming a form within the limits of reasonable mechanical construction. I will take an aperture twice the length of *this*, and half as narrow as *this* is, which will present the same amount of area, and the valve to be of the exact form of that area. Now, then, when you slide the valve over *that* one-eighth of an inch, will that present

as large an amount of area as if you lifted it up from the 974
surface an eighth of an inch?

A. No.

Q. Carrying that proposition to any extent, do you do anything more than change the degree of difference?

A. The degree of difference between what?

Q. Between the valve that lifts from its seat and the valve that slides over its aperture?

A. Just exactly the same.

Q. In view of that, is there the same necessity for giving a rapidity to the valve in opening the port at the start of
the engine, when working with puppet-valves, as there is 975
with a rotating or slide-valve?

A. If that was all the point about it, there would not be any more necessity.

Q. Do you find anything in Sickels' patent which calls for any invention in the mode of opening the valves?

A. I do not know that it asks for any improvement.

Q. Is there any improvement in the mode of opening valves in Sickels' patent? Does he profess to have any invention in the mode of opening valves?

equivalents

A. I do not remember about that. I cannot say, without
examining the patent, whether he does claim anything in 976
the opening of the valve.

Q. You said something, in answer to a question, that the description in Sickels' patent would not instruct you how to construct the defendants' apparatus; I will ask you whether the description of a watch will instruct you how to construct a clock?

Watch
Clock

A. It would depend upon what sort of a clock it was.

Q. Take the watch in your pocket, would it instruct you how to construct a clock with a pendulum?

A. No. 977

Q. Is not a clock, so far as regards its mechanism as a mode of measuring time, substantially the same as the mechanism of a watch?

A. So far as the result is produced, it is the same.

Q. Is not the pendulum which governs the escape in a clock the equivalent of the balance-wheel which regulates a watch?

A. So far as they are measurers of time, they are equivalent.

Q. Would the description of a steamboat engine enable 978
you to construct a locomotive engine?

A. Probably not.

Q. Are not both the principles substantially the same?

A. So far as the application of steam to produce motion, the principle is the same.

Q. Are not belt-wheels well-known mechanical equiva-

Bryant ex

979 lents for cog-wheels, for the purpose of communicating motion?

A. As a means of communicating motion, they are. As a means of communicating accurate motion, they are not.

Q. Would the substitution of one for another constitute an essential change?

A. It might.

On being *re-examined* by *Mr. Jenckes*, the witness, MERTOUN C. BRYANT, testified as follows:

Q. Do you consider a locomotive and a marine engine to
980 be substantially the same apparatus?

A. No, sir.

Q. Do you consider a watch and a pendulum-clock to be substantially the same apparatus?

A. No, sir.

Q. Upon the drawing produced to you by the plaintiffs' counsel, and shown to you, where is the chain or loose connection placed?

A. It is placed over the valves.

Q. With regard to the valve and the point of engagement?

981 A. Between the valve and the point of engagement.

Q. Is not the weight of the valve continually depending upon that chain?

A. Yes.

Q. Is there any moment in the motion of the engine when it is not so depending?

A. The valve will either depend upon the chain, or else it will depend upon its seat.

Q. What will be the effect of the weight of the valve
982 upon the chain—will it leave it loose or keep it extended?

A. It will keep it perfectly straight all the time, if it acts as it ought to.

Q. If you place the loose connection in the defendants' engine between the valve and the point of engagement, what would be the effect? Is it substantially in the same place, with reference to the working parts in the drawing, as in the defendants' machine, where a loose connection is
983 attached to the weight?

A. No; it is not.

Q. Where would be a corresponding place in the piece of machinery before you (DeLaine engine)?

A. This drawing exhibits a chain to exist between *that* and the valves. When you make an arrangement similar to a loose connection instead of *that* rod, then the loose connection is between the point of attachment and the plunger, that is, between the lifter and the plunger.

Q. Suppose, in Sickels' machine, you place a loose connection between the point of engagement and the plunger, how would it work? 984

A. It would work just as well without it as with it. It would render the action of the plunger inoperative.

Q. Would it not be the same thing as taking away the dash-pot entirely?

A. It would be just as well without it.

Q. In placing the loose connection between the weight and the arm to which it is attached, what effect does it have upon the operation of Corliss' machine?

A. The effect is to entirely prevent any action backward 985
from the weight to the other parts of the valve-gear.

Q. Would or not the weight be raised the same as before?

A. Yes.

Q. What would be the effect in arresting it? Will there be any change?

A. I do not think there would.

Q. In effecting the disengagement upon the machine parts of which are produced, (De Laine engine,) where is the friction that is to be overcome between the catch and the valve-stem? Point it out. 986

A. In the annular grove, lifting up the upper part of that, and on *this* catch.

Q. Where is the friction in the disengagement upon the defendants' machine?

A. Between the two hooks—the hook and catch.

Q. Is there any other friction in the defendants' than what is caused by the drawing of the two faces of metal in opposite directions?

A. No.

Q. In this portion of the machine (De Laine engine) is
there any other friction than what is caused by the drawing 987
of the latch—the friction between the latch and the portion of the valve-stem which rests upon it?

A. Yes.

Q. Point out the friction to be overcome.

A. The friction of the latch striking the incline.

Q. What friction has worn away this piece of metal?

A. The friction of *that* metal against *this* arm, I suppose.

Q. Is that in addition to the point of engagement?

A. Yes.

Q. Do you find any such friction in the defendants' machine?

A. No.

Q. Is there not friction caused by the contact of the latch and the valve-stem?

A. Yes.

Q. Point it out.

988 A. The latch enters into the groove in the valve-stem, and between the latch and the valve-stem lies a certain amount of friction.

Q. How long does that friction continue?

A. It continues from the time it begins to unlatch until it is completely unlatched.

Q. Do you find any such amount of friction in the defendants' machine—the one last named?

A. Between the lifter and the valve-stem?—No.

Q. In the machine before you (De Laine engine) is there any friction between the catch and the valve-stem, after
989 the detachment is effected, while the valve is falling?

A. Yes, there is a little. This lever is placed against the valve-stem, and, as the valve falls, there is a greater friction between it and the valve-stem.

Q. How would the effect of the combination with the governor help the friction?

A. As long as they were acting to release them, they would modify the action of the governor, and tend to destroy its effect.

Q. In the model produced to you by the plaintiffs, is not
990 the portion said to represent the valve-stem moved by a circular motion, the motion of an arm which moves upon a rocking-shaft?

A. Yes, that is the way in which it is arranged.

Q. Suppose *this* arm to be of sufficient length to move a valve of the size of *that* in the machine, would the motion of the end of the arm correspond with the rectangular motion of the valve-stem?

A. The motion of the arm would be circular, and that of the valve-stem would be in a line. It would not work.

991 Q. How would it work in a machine constructed as represented in the model?

A. On these models you cannot readily tell; but that particular point of course would not work.

Q. Will you state to the jury the experience that you have had in relation to machinery?

A. I was educated for an engineer. My education began with that view, and the first experience of much account that I had was at Lowell, to which place I went, and was
992 engaged in the erection of some mills, and in the arrangement and adaptation of their machinery. It was a very large establishment and had a great variety of machinery of different kinds. Most of the parts I had occasion to plan and lay out.

Q. Have you been an inventor of any machines?

A. I have made one or two machines for weaving.

Q. Will you look at the machine now presented to you, (an indicator) and say whether it is the one which was ap-

plied to the defendants' engine, of the results of which you 993
have spoken?

A. I have no doubt it is the same thing.

Q. What do you call it?

A. An indicator.

Q. Who was the inventor of that apparatus?

A. It was discovered by Watt. I believe.

Q. Describe how that acts?

[Witness here pointed out its action to the jury.]

On being further *cross-examined* by *Mr. Keller*, the witness MERTOUN C. BRYANT, testified as follows:—

Q. You stated that in the defendants' there were no such elements of friction as took place in the plaintiffs', between 994
the catch-lever and inclined plane; now just step around here a moment to the defendants' model; does not that hook-rod rub in contact with that adjustable stop, to effect a disengagement?

A. I think that rod acts instantaneously.

Q. I ask you, does it not rub in contact with that stop to effect a disengagement?

A. It slides in contact with it to a certain extent.

Q. Does it not enough to effect the disengagement of the latch?

A. Yes.

Q. Does it slide in contact with it any longer than to effect a disengagement?

995

A. No.

Q. Then how could you swear that there was no such element of friction in the defendants' as was found in the plaintiffs', to effect the disengagement?

A. Because I consider that the disengagement is practically instantaneous in the defendants'.

Q. In addition, in the defendants', is there not a friction of the hook-rod upon the wrist-plate?

A. Yes.

Q. Is there any such friction as that in Sickels'?

A. There is no wrist-plate in Sickels', and cannot be any such friction.

Q. Is there not a friction *here* to effect the disengage- 996
ment between the latch and the arm, which is equivalent to the friction between the latch *there* and the groove; I do not say an equivalent in quantity, but is there not an element of friction in both, corresponding in that point?

A. Yes, a certain amount of friction takes place in disengagement in both of them.

Q. You spoke about a friction *here* of the latch, after the disengagement; would that friction affect the governor, if one should be applied?

A. It would depend upon how it was applied.

997 Q. Applied in the manner that was pointed out to you on your cross-examination?

A. No, sir.

Q. In enumerating the various points of friction that would affect the sensitiveness of the governor, how do you swear that the friction in contact with *that* stem, after liberation, would be one of them?

A. I do not think I did.

Q. Now, sir, in *that* model there is a circular motion in connection with a straight motion of the valve-stem; do you not know, as a mechanician, that there are various modes
998 of connecting a circular motion with a straight motion?

A. One is very frequently derived from the other.

Q. Now could you not imagine that connection to be formed by any of the known modes of connecting a circular with a straight motion?

A. Yes.

Q. Have you not one in this model of the Watt arrangement, in connection with the valve-stem?

A. Yes, sir.

Q. Is there any difficulty in forming a connection of that sort, between the valve-stem and the rocking-arm?

A. There is no difficulty in forming a connection in that
999 model; by putting on guides you can make it move in a line.

Q. As a mechanician you could do it?

A. I could.

The Court then adjourned to January 5th, 1855, at eleven o'clock, A. M.

January 5th, 1855, 11 o'clock, A. M.

The defendants then called as a witness *Thomas B. Stillman*, who, having been duly sworn, was examined by *Mr. Jenckes*, and testified as follows:

Q. Where do you reside?

A. I reside in New York city.

1000 Q. What is your occupation?

A. An engineer.

Q. Where is your place of business?

A. At the Novelty Works.

Q. What is the business carried on at that place?

A. Steam-engine-building and other machinery.

Q. What is the name of your firm?

A. Stillman, Allen & Co.

Q. How long have you been engaged in business?

A. Twenty-five years.

Q. Have you had any practical acquaintance with steam-machinery?

Stillman

A. Yes, sir. 1001

Q. For what period?

A. For 25 years.

Q. In what way have you been acquainted with it?

A. In the construction of steam-engines and their operation.

Q. What kind of engines have you built?

A. The greatest value probably would be of marine engines; the greatest number would be of stationary engines.

Q. How many have you built in each year, upon an average?

A. I cannot tell.

Q. Cannot you give an average? 1002

A. I never made a sum of all that we have built; I suppose several thousands, altogether.

Q. Have they been built upon different plans?

A. Yes, sir.

Q. Are you acquainted with the different modes of constructing steam-engines used in this country?

A. Most of them, I suppose.

Q. Are you acquainted practically with the devices and combinations used in steam-engines?

A. Yes, sir.

Q. Have you examined the patent granted to Frederick E. Sickels in 1842, and the specifications and drawings ap- 1003 pended to it?

A. I have seen them.

Q. Do you know what is there described and represented?

A. I suppose I do.

Q. Will you state what you understand to be the invention described in the first part of that patent?

A. This model (plaintiffs') represents a section of the steam-chest and side-pipe; *this* column represents one of the side-pipes. There being one for steam and one for the exhaust steam, a cut between the two makes the section of a steam-chest, in which the steam-valves appear. The apparatus of Mr. Sickels is attached to the steam-valve for the 1004 purpose of interrupting the flow of steam into the cylinder at the required point of the stroke. The method of controlling the steam formerly used, was, by attaching the valve, through its lifting-rod, to the eccentric—a constant connection—so that the steam-valve would be lifted and lowered to its seat simultaneously with the motion of the eccentric, and consequently there would be no interruption of the steam during the descent or ascent of the piston. That was effected, however, by a valve, placed in the steam-pipe; sometimes in the form of a damper to a stove-pipe, and regulated by a spring.

1005 *Mr. Keller.*—There are different forms of them?

A. Yes, there were different forms of these valves. They were more generally used in the steam-pipe, the same as a damper in a stove-pipe. Sometimes they were made otherwise, but with substantially the same mode of operation. In making use of the steam-valve for the double purpose of regulating or admitting the steam and of interrupting it, an apparatus was found necessary which had not been used in the former method or mode. The steam-valves are very heavy, are generally made of brass, and in large marine en-
1006 gines weigh several hundred pounds—as much as a man could lift, sometimes. In dropping them to their seats suddenly there would be a concussion or slam, which is not only very annoying, but destructive of the parts, tending to beat the seat out of form—out of its proper place, and abrade the surface at the point of contact. The plan of Mr. Sickels was applied to the use of this valve, as a means of disengaging it in its ordinary and regular operation, and arresting it, so that it should not strike severely upon the seat—arresting it by other means than by the naked seat. In this specification or schedule, *this* represents the valve-box
1007 containing puppet-valves. *This* is a recess into which the steam enters. When this valve is lifted it passes to another part, and so on in its course. This part of the apparatus was well known before, as stated in the schedule. B is the valve-stem, which is a stem passing through and firmly fixed to the valves, connecting the upper and the lower, as they are double and balancing each other—connecting the two valves together firmly, rigidly; so that, as the seats are never moved relatively, the valves may not move relatively
1008 —each keeping its proper distance, so that both may be seated at the same point of time. *This* is called a lifter, which is to lay hold of the valve-stem and give it the motion which is given to the lifting rods in the ordinary arrangement. *Here* are springs which form a part of the disengaging apparatus. The upper end of the stem is flattened, or has projecting feathers or edges, by which the valve is lifted, the spring catching under it. By the sliding pieces, the grooves and wedges moving on the sliding piece, the valve may be disengaged at any point of the stroke.
1009 The wedges are kept in place upon the sliding-piece by a screw, fixing them firmly at any desired point.

Q. Will you name the parts or elements that compose that apparatus?

A. The valve-stem, spring-catch, sliding-piece, wedges and the set-screw.

Q. Are you acquainted with the engine used by the defendants, Youngs & Cutter?

A. Yes, I have seen it in operation.

Q. Do you understand the construction and mode of 1010
operation of that engine?

A. Yes, sir.

Q. Have you examined the model before the jury, and
if so, does that represent the defendants' machine?

A. That is a good representation of the machine.

Q. In your opinion, as a mechanical engineer and prac-
tical builder of steam-engines, is the construction, arrange-
ment or combination of the apparatus used by the defend-
ants for more readily cutting off steam in working the
steam-engine, substantially identical with the construction,
arrangement or combination of the apparatus described in 1011
the specification of Sickels' patent?

A. I consider it substantially different.

Q. Will you state the points of difference?

A. In the first place, the valves are of a different charac-
ter, consequently requiring a different application of appa-
ratus for their government. That difference is found in the
machine to correspond with the difference in the valves.

Q. Will you state more particularly the kinds of valves
and their differences?

A. The valves found in connection with Mr. Sickels' ar- 1012
rangement are puppet-valves, which I have described be-
fore, and which are lifted from their seats. Their motion
is perpendicular to the plane of their seats. The motion of
Mr. Corliss' valves is parallel or coincident to the curve of
their seats. The valves in Mr. Sickels' must necessarily be
very nicely adjusted. The extent or termination of their
motion must be nicely adjusted. The valves used by Mr.
Corliss do not require such a nice termination, because their
contact with the surface of the seat does not produce the
same effect. They may be said to be always in contact 1013
with their seats and never lifted from them. Their motion
is sliding, a sliding motion upon the seat. As they are
never lifted from it, they can never slam by being brought
into contact with it. It is a very different character of
valve. The slide-valve, as used in the defendants' machine,
is peculiar in itself, and different from the ordinary slide-
valves used in high-pressure and other engines. It is a ro-
tating valve, having a centre, and a consequent circular
motion. Ordinary slide-valves move upon a plane, back-
wards and forwards, and so are made to cover the ports. 1014
This represents the motion of Mr. Corliss'. *There* is the
valve, *there* is the steam-chest, and *there* the seat. *That*,
moving in *that* direction, opens the port for the steam on
one side, and, on the other side, merely by passing over the
opening, compels the steam to pass into the cylinder and
perform its office, and, having done so, allows it to escape
into the atmosphere. This valve has no rod attached to it.

Stillman D

1015 Its contact with the seat preserves its position. Dispense
with the rod in the Sickels' valves, and they would not conform in position to the seat; the seat being fixed, the valve would not conform in position. There would be nothing, at any rate, to control its position. It might fall upon the side, off its seat. The rod being a central point of attachment, controlled by guides, causes the valve to descend always directly upon its seat. Here, (taking model of Watt's invention,) is a valve and its corresponding seat.
1016 The rod being sustained above and below, keeps the valve
in its proper direction while in motion, and brings it to its seat firmly, without allowing it to strike on one side or the other. It therefore necessarily must have a rod, or some analogous contrivance, to conduct it to its seat properly. The valve in Corliss' needs no such thing, because it rests upon its seat, and only wants motion upon that seat. *This* (puppet-valve) wants motion and direction. That motion and direction cannot be given by its seat properly and safely. Therefore, puppet-valves and rotating or slide-
1017 valves, are substantially different in their construction and
mode of operation—substantially different. The rotating-valve corresponds more nearly to the slide than the puppet-valve, as its motion is that of sliding upon its surface, always in contact with its seat, as the sliding valves are.

Q. Do they or not require different kinds of valve-gearing?

A. They do.

Q. Will you explain the differences, if there are any, between the valve-gear described in Sickels' patent and that used by the defendants?

1018 A. [Witness described the operation of the valve-gear on
the model of Mr. Corliss', adding:] The apparatus which works these valves is entirely different from that which works puppet-valves. The apparatus for disengaging is necessarily different. *Here*, in place of the adjusting screw, fixing the point of cut-off and closing the valve, the governor holds by its own arm—its own force—holds a control of a fulcrum. That receives a motion from the governor, and not from the hand of the engineer. Upon that fulcrum acts a lever, one end of which receives its motion from
1019 what is called a wrist-plate, through this pin—an up and
down motion—which serves to disengage this valve and allow the descending weight to bring the valve back to its place before the piston shall have reached the end of its stroke. In Sickels' arrangement he has a dash-pot. *Here* is something analogous, but essentially different.

Q. Will you describe what the usual way of operating valve-gear was in 1842, at or about the date of that patent?

A. The valve was lifted by an eccentric, and lowered to its seat without any detachment.

Q. Is it exhibited in any of the models present? 1020

A. Do you mean the valve-gear in Sickels'?

Q. Yes, I mean the valve-gear itself. How was the lifter operated, as described in the patent of Sickels', the lifter and lifting rod?

A. It was lifted by the eccentric. This rod and this lifter were not materially altered. They were in some machines altered so as to introduce the arrangement in Sickels', by simply putting a sliding piece, with a catch, altering the end of the rod, and making a disengaging motion by the direction of the standard. But the eccentric operated both lifting rods, upon each of which was attached a steam-valve 1021
and an exhaust-valve. The exhaust and steam-valves were lifted simultaneously.

Q. Will you describe the operation of the spring upon the Sickels' model?

A. The spring in this model, more accurately described in the specification, is attached to this lifter; it is an attachment upon the upper surface of it, supporting the lifter, receiving its strength from the lifter to lift the valve, and playing into the shoulder formed upon the valve-rod, so as to connect it—the spring passing a wedge in its upward stroke; this (mahogany model) is not a very perfect model; 1022
it will be seen where those springs occupy the neck portion of this rod that they are more nearly together than when upon the rod itself; in ascending, those springs are separated by that wedge, and sufficiently separated that the valve shall drop; on reversing this wedge-piece the springs are made to close in passing upwards; in passing down, they would be separated by coming on the outer portions of the wedges, so that the valve will drop; this wedge-piece being fixed, detaches at any portion of the stroke, or, by 1023
being inverted, it would detach the valve on the descending motion of the valve, and is the adjustable point of Mr. Sickels' patent.

Q. Do you find that spring, or any equivalent for it, in the defendants' machine?

A. No, sir.

Q. Within what limits can the steam be cut off in the defendants' machine?

A, Within half of the stroke of the piston.

Q. Will you explain the purpose of the adjustable slid- 1024
ing piece in Sickels' model?

A. It is for the purpose of cutting off shorter or at a greater length of stroke.

Q. Does it, or not, control the point of cut-off?

A. Yes.

Q. Do you find any such adjustable sliding piece, with its inclined planes, or the equivalent of that device, in the defendants' machine?

1025 A. No, sir.

Q. How is the detachment effected in the defendants' machine?

A. By the governor, through a lever acting upon a fulcrum—upon a movable fulcrum.

Q. Do you find any standard or set-screw in the defendants' machine, or their equivalents?

A. No, sir.

Q. What is the purpose of the standard and set-screw in Sickels' machine?

1026 A. It is to hold the inclined planes in a position to be acted upon by the springs.

Q. If the screw were not set, what would be the effect of the contact between the springs and the inclined planes?

A. The inclined planes would move with the springs.

Q. Would, or not, any cut-off be effected in that case?

A. There would not.

Q. What is the effect of the connection with the governor in the defendants' machine?

1027 A. It controls the point of cut-off, so as to regulate the motion of the engine, to make it uniform, whatever may be the resistance.

Q. What was the usual mode of regulation of the stationary engine?

A. A governor attached to an independent valve, similar to that formerly used for cutting off the steam.

Q. Where is that valve situated?

A. In the steam-pipe.

Q. How was the regulation in that case effected?

1028 A. By closing the area of pressure of the transmission of steam, or opening it, according to the resistance offered to the progress of the engine.

Q. What effect did it have upon the steam itself, or its tension?

A. It reduced the tension between the piston and the valve, or increased it.

Q. What effect does that have upon the working power of the steam?

A. It has an influence to deprive it of the expansive
1029 force which it would otherwise have upon the piston, and make it less economical.

Q. What do you understand to be the purpose of the apparatus described in the second part of Sickels' specification?

A. It relates to the dash-pot; the dash-pot, as I before observed, is for the purpose of arresting the descent of the valve or valves, to prevent a slam.

Q. Would the apparatus described in the first part of the specification work usefully or not, in your opinion, except in combination with this dash-pot?

A. It would not. 1030

Q. Why not?

A. From the force which the valves and stem would exert upon the structure of the machine.

Q. At what period in their descent do the valves become checked in Sickels' apparatus?

A. Within a short distance of their seats, in other words, it breaks the force of the valves before they arrive at their seats.

Q. Is, or not, this necessary in puppet-valves?

A. It is.

Q. How is it with reference to other kinds of valves? 1031

A. In the defendants' apparatus it is not necessary to arrest the valves so suddenly; but the object is to give them greater velocity; there is no gravity to bring them to their place except a weight for that purpose; it tends to bring the valves over their openings, and, never being lifted from their seats, they want no device to bring them to it.

Q. Do you find in the defendants' machine any arrangement or apparatus for preventing the slamming of the valves?

A. There can be no slam, and, therefore, there is no ap- 1032
paratus for preventing it.

Q. What is the object of the apparatus you find in the defendants' machine?

A. The object of the dash-pot, or that which resembles in appearance a dash-pot, is to arrest the weight in its descent. After having accomplished its object, by bringing the valve over its opening, it must itself be arrested, and the dash-pot is to afford the cushion or soft elastic material upon which the weight may fall, without itself making a jar; it is in effect entirely different from that effected by 1033
the Sickels' arrangement.

Q. Is it or not necessary to have the connection between the valve and the weight rigid?

A. It is not in the defendants' machine.

Q. Why is it not?

A. It is simply to arrest its own motion that the dash-pot is applied.

Q. Suppose the weight to be connected with the arm by a leather strap, would there or not be any jar communicated from the weight to the valve?

A. I have seen an engine worked with precisely such an 1034
arrangement; the pot here, which corresponds in appearance to the dash-pot of Mr. Sickels', would be deceptive, perhaps, to some, if they had not looked closely into it; it is merely a guide for the weight; the chamber below contains sufficient air for the purpose of an elastic cushion; this weight, therefore, descends freely until it strikes the

Silliman D

1035 confined air which serves as an elastic bed on which to rest; a leather strap in place of a rod, is sufficient for the purpose of bring the valve to its point of termination; that is necessary, because the valve, in pressing upon its seat, and being pressed upon by the steam, would be arrested by that friction, and would not terminate its stroke properly, without the application of an external force; that shows the great difference in the construction of the valves; in Sickels' arrangement of puppet-valves, which descend, from the force
1036 of steam and their own gravity, to their seats, they would ruin and destroy themselves by their own action, if left to themselves; whereas the application of a weight is necessary there, to bring them to the point, they not having that power within themselves; being brought so as to cover the opening, there is no further necessity of motion to the weight.

A. In the Sickels' apparatus, is it or not necessary to have the connection between the valve and the plunger firm?

1037 A. Yes, sir.

Q. Explain why?

A. In this model the plunger in the dash-pot is situate below the valve; should there be a chain or strap connection, it would not afford any resistance to the progress of the valve; the valve would not drop, and the strap would merely double up—fold—allowing it to descend in its own way.

Q. Suppose, in the black model before you, there was a loose connection between the spring on the lifter and the
1038 valve, what would be the effect?

A. The effect would then be to arrest the descent of the valve; but, without some other contrivance, the whole apparatus would fall, when disengaged, to the ground; this attachment which here now supports it by the rod would fall over with the strap, and would not be found when required to be picked up again by the apparatus.

Q. Where would be the corresponding place for a loose connection in the Sickels' machine—corresponding to the
1039 strap you have already described in the defendants' machine?

A. I do not understand the question.

Q. In the defendants' machine you have described a strap connecting the weight with the arm that moves the valve; where would be the corresponding place for a strap, chain, or other loose connection in the plaintiffs' machine?

A. It would be between the valve and its connections.

Q. Point it out upon the machine?

A. *That* is the point of engagement, and *this* being the lifter, and *this* the spring upon the rod, it would be between the valve and *this*.

Q. Where would the dash-pot be situate in that case? 1040

A. Necessarily under the valve; there would be no connection between them.

Q. Supposing the dash-pot to be situated as represented *here*, where would be the corresponding place for a loose connection?

A. About *there*.

Q. In your answer to the first question upon this subject, where did you suppose the dash-pot to be situate, when you placed the loose connection in the position you have indicated? 1041

A. Underneath the valve which is represented in that model.

Q. Will you now examine this drawing (handing it?)

A. Here a chain is introduced between the valve and the engagement to the apparatus for disconnecting.

Q. Where is the dash-pot?

A. The dash-pot is above.

Q. As represented in that drawing, is the loose connection in a corresponding place with the strap upon the defendants' machine? 1042

A. No, sir; in a different place.

Q. What is the object of the adjustable cup in Sickels' machine?

A. So as to bring the fluid contained, in a proper relation to the seat of the valve, so that the weight may be arrested at a proper point.

Q, Do you or not consider it to be a substantial part of that apparatus?

A. Yes, sir.

Q. Will you examine the defendants' machine, and see whether or not you see any secondary reservoir there? 1043

A. There is none, and no necessity for it.

Q. Why not?

A. Because, in arresting the descent of the valve, there is nothing so accurate required as that adjustment; for, whether the weight falls a little more or a little less than to its ultimate point, so that the valve covers its seat, is not material.

Q. When should the weight be arrested in the defendants' machine? 1044

A. When the valve has covered its seat—any point between the point at which it is covered, and that extent which the lap of the valve itself allows; in *this* (Sickels') when the valve is closed, it can go no further; it allows of no further motion than to its positive termination; preceding that instant of adjustment, it is necessary to check it; whereas, in the defendants', the valve need not be arrested until after the opening is closed by the valve; that liberty

Stillman D

1045 or limit may be extended by extending the limit of the lap of the valve.

Q. Have you observed any result in the defendants' machine, from the motion of the valve upon its seat, before the port is open. If so, state what result?

A. The progress of the valve, at the point of closing the port, effects a much more sudden action upon the steam than if interrupted in its progress before that period or that point of retardation, so as to be seated upon its seat without injury. The rapidity of motion conduces to the rapid or
1046 sudden cut off of the steam, and therefore leaves the steam from the boiler to act at greater tension upon the piston until the valve is closed; because the longer the steam in its highest tension acts upon the piston before being cut off, the more effective will the expansion be, and the more economical will it be.

Q. Will the description in Sickels' specification teach you, as a practical builder of steam-engines, how to construct the machine of the defendants?

A. No, sir.

Q. Will you state what, if any, guide it would be to you
1047 in the construction of the defendants' machine, or whether it would be any?

A. Very little guide in any respect. It differs from the ordinary high-pressure engine, so that its peculiarities seem almost to place it in another character of arrangement. It is so different from the ordinary slide-valve or valves (there being four of them) and rotating valves, controlled by the governor in the manner set forth, that it would be no guide in the construction of either puppet-valves or ordinary slide-
1048 valves; neither would either of these forms be any guide to the construction of this, (Sickels'.)

Q. Does the result obtained in the engine of the defendants differ in kind or in degree from that obtained by the apparatus of Sickels?

A. It is different in kind. The result in the defendants' machine is to equalize the motion through the cut-off valve. The result in the plaintiffs' machine is to economise steam, without in any way controlling the velocity of the engine,
1049 or regulating it.

Q. How much does the weight used in the defendants' machine, for the purpose of closing the valves, weigh?

A. (Testing it.) It seems about the size of a fifty-six.

Q. What is the power of that engine?

A. Twenty horse-power.

Q. How do you estimate the horse-power of engines?

A. The rule universally adopted for a horse-power is the power to raise 33,000 lbs. one foot high in a minute; or 1

lb. 33,000 feet, the velocity having as much to do as the weight. 1050

Q. How many times does that represent the power of this engine?

A. Twenty times 33,000 lbs. will give 660,000 lbs.

On being *cross-examined* by Mr. *Keller*, the witness, Thomas B. Stillman testified as follows:

Q. To what capacity of engine would *these* puppet valves be suitable?

A. In a low-pressure engine, they are about the size we use for a fifty horse-power—about the size of an ordinary 1051
ferry-boat's valves. In our large steamers we have them twenty ~~inches in diameter.~~

Q. Twenty inches in diameter—then what is the power of the engine?

A. Nominally one thousand horse-power. There is nothing very exact required, so that they are large enough. If they are larger than necessary, there is no other result than requiring additional power—more machinery—cost of construction, &c.

Q. As a general rule which work easiest—the balanced 1052
puppet-vales, or the slide-valves?

A. In our large engines we use balanced puppet-valves, mostly—almost universally.

Q. Is it because they require less power to work them?

A. Yes; because they balance themselves, and have less friction.

Q. Which will give the greatest area of opening with a given amount of motion—the puppet-valve or slide-valve—assuming the port to be of the same area in both cases?

A. That depends upon the proportions of the ports.

Q. Taking the usual proportions that are practiced? 1053

A. It is designed always to give them a rapid opening—to open them as rapidly as it can be necessary to fill the cylinder; and the velocity with which a slide-valve is opened, the form of the port, as well as the area of the port, have to do with that question, and it depends upon the adjustment of those relative elements.

Q. Suppose you have a valve that just covers the area of that port, which will present the greatest area of opening for the admission of steam—to lift the valve from its seat one-eighth of an inch, or to slide it over the port one-eighth of an 1054
inch?

A. That would depend upon the proportions.

Q. Taking these proportions?

A. It would require calculation to know what the proportion to the circumference of a valve would be.

Q. I am taking *this* identical form of aperture, with a

Stillman

1055 value just covering *that;* which would present the greater area of opening for the admission of steam—to lift up the valve from its seat one-eighth of an inch, or slide it over the port one-eighth of an inch?

A. As I said before, that would depend upon the relative open area.

Q. I am speaking of this identical port?

A. To take that same valve, it would of course—

Q. Within any of the proportions that are given to steam-ports in practical engines, either of the defendants', or of any
1056 other in which the valve slides over the port, and taking an equal area of opening presented by the port of a puppet-valve—will not the raising of the puppet-valve present a larger area of opening in the first opening, than with a slide-valve?

A. In practice it does not result in any difference.

Q. I am now speaking with regard to the beginning of the opening.

A. It will be understood that a statement, in order to cover the ground of the question, must be made to give place to the effect of motion, rapid or slow, as well as the propor-
1057 tion of any opening in a slide-valve; because motion has to do with puppet as well as with slide-valves, and the shape or form of opening in slide-valves has as much to do with it as motion; but in the puppet-valve the form is fixed—it opens in the form of an annulus, and the steam comes out as a hollow cylinder.

Q. Assuming this port, in the model of Sickels', to be of equal capacity with the port in the defendants' engine, and assuming *this* valve to rise from its seat one-eighth of an inch, while *that* valve passes over the port one-eighth of an
1058 inch—which will present the greater area of opening for the admission of steam?

A. If the circumference of that valve is greater than the length of that opening, it will do it.

Q. I am taking the openings as presented in the plaintiffs' and defendants' engines?

A. Those engines must be constructed upon the same scale, in order to give the eye any idea.

Q. Cannot you conceive two engines—one with puppet-
1059 valves and the other with rotating valves, with the same area of opening and the same capacity of cylinder, to be built?

A. I can conceive that effect to be precisely the same in both cases.

Q. When you move the puppet-valve an eighth of an inch, and the slide or rotating valve an eighth of an inch, which will present the larger area of opening for the admission of steam?

A. I do not know that it is a question that can be

answered; and the reason is, that there must be a propor- 1060
tion fixed. You must give me, in order to answer that correctly, the openings in the two machines. Without it, I cannot answer.

Q. Have I not asked you to conceive the area of the ports to be of the same capacity?

A. That has no relation to the question.

Q. Why not?

A. Because the area has no relation to the form of opening.

Q. I told you also, as another branch of my question, to
take the form of any two engines that you have seen, as 1061
constructed by Corliss?

A. If you will let me take a slide or rotating valve, with an opening as long as the circumference of the puppet-valve, the answer will be very direct. If the opening of the slide valve be not so long as the circumference of *this*, to get an equal area of opening, you must open the slide-valve more, give it a greater velocity, and make a wider opening than one-eighth of an inch. You may do that, and have a result precisely the same; but you must have an equivalent, either
in velocity of motion or the width of the opening. 1062

Q. As a general rule, are the ports of either rotating or sliding valves made as great in length as the circumference of a puppet-valve?

A. They are not.

Q. Then, sir, taking that as a standard at which the length of the port for a slide-valve is made, (of less length than the circumference of a puppet-valve,) and the valve to move in both cases one-eighth of an inch?

A. We do not, in that case, move them with equal
motion. 1063

Q. Then, moving the valves at the same time and the same distance, will not the puppet-valve present a greater area of opening?

A. It presents a fallacy.

Q. Where is it?

A. If the area of the opening in the puppet-valve be the same as the area of opening in the slide-valve, the puppet-valve must be taken away from its seat so far that the
annular space around it is equal to the whole area of the 1064
opening. In a slide-valve, the valve is moved over the entire opening, presenting an opening unobstructed. Then, for an engine of equal power, you want an opening equal to the area, to produce the same effect, and, if that entire area is opened in the same time, the velocity of the engine being the same, the result would be the same. If you confine a puppet-valve to a motion of three inches and a slide-valve to the same, you may have one open and the other not.

1065 Q. Will you confine yourself to my question, and show
me where the fallacy of it is?
A. The fallacy of the question is in supposing it necessary
to confine the motion of either valve to one-eighth of an
inch.
Q. I am not speaking of the entire working of the engine.
I have a purpose beyond that; and, for that reason, I limit
it to one-eighth of an inch; and I should like to have an
answer to my question, if you feel disposed to give it?
A. Repeat it.
1066 Q. I want to know whether, in view of the area of the
port in the defendants' engine being of equal area with the
port for puppet-valves, and the slide-valve moves to open
its port one-eighth of an inch in the same time that the
puppet-valve will be lifted one-eighth of an inch—which
will present the greatest amount of area for the admission of
steam up to that extent of motion?
A. If you mean by lifting *this* an eighth of an inch,
opening it an eighth of an inch, it will be precisely the
1067 same; for an eighth of an inch in one will be the same as
an eighth of an inch in the other.
Q. Would that present the same amount of opening for
the admission of steam?
A. Precisely the same.
Q. Recollect that you stated, that the length of the port
in sliding valves is not equal to the circumference of the
puppet-valve?
A. That is another question. Then I do not yet understand you
Q. Have you not already admitted, taking the general
1068 form of the port in the defendants' engine, that the length
of a port, for a given amount of area, would not be equal to
the circumference of the puppet-valve?
A. Yes, sir.
Q. Then, the valve moving in both cases to the extent of
one-eighth of an inch, in an equal space of time, which will
present the greater area for the admission of steam?
A. The one having the larger extent, of course.
Q. Which is that?
1069 A. Probably the puppet-valve.
Q. Have you any doubt about it?
A. I do not know that I have.
Q. Is it not, as a general rule of mechanics, easier to start
by hand-balanced puppet-valves than slide-valves?
Q. It is, where they cover the same opening—ports of
the same dimensions.
Q. Were the engines of the *Baltic* built at your establishment?
A. No, sir.

Q. Which of the Collins' steamers were built by you ? 1070
A. The *Atlantic* and the *Arctic ?*
Q. What is the difference in power required to start those valves by hand, compared with the sliding valves used in the Cunard steamers ?
A. The actual power required is very materially less.
Q. As the puppet-valves are generally operated, do they not admit steam sufficiently fast at the time of starting the piston ?
A. They do, if their size is sufficient.
Q. Their capacity for working the engine being suffi- 1071
cient ?
A. Yes. It is for that purpose that valves are made of greater area than would otherwise be necessary.
Q. Do you find any necessity in the construction of engines with puppet-valves, for giving the valves a more rapid motion at the time of starting ?
A. No, sir, we have to retard them sometimes on board of steamers.
Q. Do you know how long it is since check-rings have
been used on puppet-valves ? 1072
A. I do not recollect ; some 12 or 15 years.
Q. Now, sir, you stated that the result in the defendants' engine was different in kind from the result produced by Sickels'; are they not both intended for the purpose of economising fuel ?
A. One is almost exclusively confined to economising fuel, and the other to economising fuel and regulating the machinery.
Q. So far as they relate to the saving of fuel, is not the purpose of both the same ?
A. All cut-offs are upon a par in that respect.
Q. Now, sir, if the engine is moving too fast in propor- 1073
tion to the amount of power generated in the boiler, with Sickels' arrangement, what would you do to check thespeed and save the steam ?
A. Use the throttle-valve.
Q. Would not you vary the cut-off ; would you not shift the adjustable piece of the cut-off ?
A. That would be one way.
Q. Would not that tend to regulate the motion of the engine ?
A. Yes.
Q. So far as that goes towards regulating the motion of 1074
the engine, is it not the same in kind with the regulation of the defendants' ?
A. It does not have the same result ; it depends upon the constant attention of the engineer ; and, it is found, that a man is not competent to regulate the motion of an

1075 engine with sufficient accuracy, by hand; therefore, the necessity of an automatic arrangement, by which it is self-regulating.

Q. Now, sir, suppose you were to add to Sickels' arrangement a governing apparatus, so as to shift the adjustable piece by the action of a governor; would that make it an entirely different invention for the purpose of cutting-off steam?

A. There would have to be an invention superadded.

Q. Would it be an invention or improvement upon his
1076 arrangement, or would it destroy the identity of the original?

A. It would destroy a portion of the original.

Q. What portion?

A. It would destroy the arrangement; it would take from this arrangement the set-screw, and destroy the combination, by taking one of its elements.

Q. That is all?

A. Yes.

Q. Is not an eccentric used sometimes, such as is represented by this brass sector, in the Sickels' model; is not
1077 such a sector-groove sometimes used as a means of adjusting the position of pieces of mechanism?

A. Yes.

Q. Would it not hold it in any place required, just as effectually as a screw?

A. If the inclination is not too great, it will.

Q. Would it require the exercise of invention to substitute a sector like this for the set-screw?

A. I suppose it would.

Q. It would require invention to substitute for the set-screw, as you find it in Sickels' arrangement, this well-
1078 known sector-groove?

A. Yes.

Q. I ask you, now, whether a person making that change in Sickels' arrangement, would be using Sickels' invention or a different invention?

A. So far as the combination patented by Sickels was used, it would be the same.

Q. Suppose, instead of looking at the patent, you take this model as an embodiment of his invention, and direct
1079 your mind to the mechanism represented there; now, sir, would the construction and combination of this mechanism be entirely destroyed—entirely changed—by substituting this brass sector for the set-screw?

A. It would change the set-screw for something else, and make a new combination.

Q. As an apparatus for cutting-off steam in steam-engines, would the substantial identity of the combination be destroyed or remain the same?

A. The cut-off would remain the same. 1080

Q. Would there be a practical difficulty for an engineer to connect the governor-rod with the arm of this sector, so as to set that adjustable piece at any position required, as indicated by the velocity?

A. Yes, very great difficulty; the power required to move that would destroy the effect of the governor—its efficient action and uniformity.

Q. Would it require any more power to work that slide, when properly constructed, than this wedge-rod in the defendants'? 1081

A. Yes.

Q. For what reason?

A. The action upon the wedges by the lifting rod is a power directly applied, which would ordinarily be sufficient to control those balls, and make them deviate from their ordinary course.

Q. Confine yourself to my question. I am not speaking of wedge-pieces. I want to know whether the governor—taking out of view the spring-catches, as a means of governing the position of the adjustable piece—would there be any difficulty in attaching the governor-rod to this, so as to 1082
adjust this adjustable-piece by the movement of the governor, just as the wedges upon the defendants' engine adjust the movable fulcrum?

A. There is no comparison in the two cases.

Q. Will you answer my question?

A. I do answer it.

Q. Now we will take away this brass sector, since it is a trouble to you, and, instead of that, we will place a horizontal sliding-rod, precisely like that, (but differing merely in form, from the fact of having an inclined groove instead of an inclined wedge,) to embrace the stem of this adjustable 1083
sliding piece, and have that connected with the governor, as in the defendant's model,—would it then adjust this stop as it does the movable fulcrum?

A. It would not be the same; because it would require more force—the power in lifting is greater than in that arrangement.

Q. Is there any more weight hanging upon these spring-catches in the plaintiffs' apparatus than there is weight hanging upon the catches in the defendants' engine?

A. There may be. 1084

Q. Is there?

A. The pressure of steam is to be added to the weight of the valve.

Q. Are those not balanced valves?

A. Not exactly; there is always an addition made to their own weight by the different area of the two valves;

1085 the pressure of the steam, constantly varying, will always vary the action of the governor, where that is uniform.

Q. You have testified that there is greater power required to work puppet-valves than slide-valves?

A. Yes.

Q. In this machine of the defendants', the valves are worked by a falling weight, are they not?

A. Yes.

Q. And the power of that weight must be sufficient to work the valves?

1086 A. Yes.

Q. In Sickels' arrangement, do the catches have anything more to do than simply to lift the valves themselves?

A. They have the same office to perform, but in a variable degree.

Q. Answer my question. In Sickels' have the catches anything more to do than to open the valves?

A. When engaged, to lift the valves.

Q. In the defendants', do not the catches have to open the valves and lift the weight?

A. Yes.

1087 Q. Is there not more power exerted upon the catches in the defendants' than in the plaintiffs'?

A. Admitting that there should be the same power required, the one would be uniform and the other not.

Q. You have sworn that puppet-valves are more easily lifted from their seats, then sliding valves are made to slide over their seats?

A. I will explain a little. The puppet-valve requires nearly all the power to be exerted at the instant of open-
1088 ing; after it is raised from its seat, (one-eighth of an inch if you please,) no more power is required upon it, or a very slight power; a blow as it were—an instant of time, overcomes that resistance; but in the slide-valve, while it continues longer, the pressure is more uniform; and that constitutes a material difference in the two valves; because, when a slide-valve covers its port entirely, it is harder to move than the balanced valve; but, having moved so as to open the port, it moves as easy as any other.

1089 Q. Must not that weight be sufficient to move the valve, when the port is closed?

A. The weight must be sufficient to close the port.

Q. Does not the weight move the valve after the port is closed?

A. It may, or may not.

Q. I ask you, as a witness, is not the weight used by the defendants in their engine sufficient to move the valve when the port is closed?

A. No sir; in instances which I have seen, the valve was

arrested, and it required a force applied by the eccentric, 1090
through *this* collar to *that*, to close the valve after the weight had stopped.

Q. When that engine is at work, is the port closed before the weight is stopped?

A. The friction of the valve itself closes it before the weight.

Q. Which was to make the valve close the port? Was it the weight or the valve itself?

A. The momentum of the weight brought it as far as it did. 1091

Q. Then is not that weight sufficient to close the valve?

A. Of course.

Q. That weight must be equal to the power which is necessary to work the valve?

A. It was insufficient to move the valve after it came to a state of rest.

Q. Assume it to be a little less. Will not the amount of power required to be exerted upon that catch, to open the valve and to lift that weight, be greater than the amount of power required to lift the valve in Sickels'?

A. It would depend upon their proportion. 1092

Q. Taking the same capacity of engine?

A. I do not know that there would be difference enough to make it any object.

Q. Would it not be materially greater in the defendants' than in the plaintiffs'?

A. No, sir; I should think not.

Q. Now, sir, you said a while ago, that it required a great deal more power to lift balanced puppet-valves than it did to move them after they were lifted. Have the catches to be liberated at the instant of opening the valve, or after 1093
the valve is opened?

A. After it is opened.

Q. Then why do bring into your answer the additional power required at the time of opening?

A. To illustrate the difference between a puppet-valve under all its circumstances and the slide-valve under all its circumstances, and its effect upon the governor.

Q. As these catches have to be disengaged after the valve is opened, will they have to sustain any more than 1094
the weight of the valves, and will that be equal to the amount of weight sustained upon the catches of the defendants' during the operation?

A. In a simple case, I suppose not.

Q. Then, sir, will it require in that case more power to open the catches in the plaintiffs' than it will to open the catches in the defendants'?

1095 A. If the catches are precisely the same in their angle—in their form—I suppose it would not.

Q. Is there any necessity for there being a greater engagement to the catches in the plaintiffs', than in the defendants'?

A. I think there is.

Q. Why so?

A. You must have an engagement sufficiently sure to prevent the valves falling of their own weight.

Q. Do you not do the same with the defendants'?

A. Yes, there is a rod which draws, but a little different.

1096 Q. What difference is it?

A. I do not know that it would be sufficient for anything.

Q. Must not the catches be so that they must ensure catching, in the plaintiffs' and in the defendants'?

A. There is no material difference, that I can conceive.

Q. Now then, sir, is not the power of the wedges, as a mechanical power, equal to the power of the lever, taking like proportions?

A. There is more loss of power by the wedge.

1097 Q. In what way?

A. By friction.

Q. Is there any loss of power by friction in the defendants'?

A. Very slight in that lever, in that portion of it.

Q. Does not the lever, at the time it liberates the catch, slide upon a movable stop?

A. It may.

Q. Does it not?

A. Yes.

Q. Then, sir, if you have a sliding motion of an equal
1098 amount of power—one to be overcome by the wedge and
the other by the lever—by what law of mechanics can one
require a greater amount of power than the other?

A. Where equal, there would be no difference in power.

Q. In view of that fact, why is it that you cannot apply precisely the same arrangement of the governor to the moving-stop of the plaintiffs' engine, to regulate the cut-off by the governor?

A. It requires some invention to do it.

1099 Q. I will supply that for you. I will have a sliding piece with an inclined groove, having the same inclination as the wedges on the sliding bar of the defendants'. I will do all that for you, and then I will ask you whether it will regulate the cut-off of the steam as it does in the defendants'?

A. The friction in this (defendants') operation is overcome by the eccentric. The friction in that (Sickels') must be overcome by the governor.

Q. The friction in this (Sickels') must be overcome by the governor? 1100

A. Yes.

Q. Does this bar slide at the moment the catches are being disengaged?

A. So far as the friction is concerned.

Q. I ask you whether the governor is capable of moving at the moment of disengagement, in the defendants'?

A. The effect would be upon that inclined plane at the moment of disengagement.

Q. To prevent the governor from moving, would it not? 1101

A. Precisely.

Q. In the plaintiffs' it will hold the governor still when disengaging; will it not leave it perfectly free to move when not disengaging?

A. There appears to be a difference *there*. There seems to be a difficulty in my own mind with regard to the moving of the eccentric.

The Court then adjourned till January 8th, 1855, at 11 o'clock A. M.

JANUARY 8th, 1855, 11 o'clock A. M. 1102

The *cross-examination* of the witness, *Thomas B. Stillman*, was resumed:

Q. At the time of the adjournment of the court, on Friday, I had directed your attention to the comparative amount of power required to disengage the valves in the plaintiffs' and in the defendants' arrangements. You were under the impression that in the defendants's arrangement the friction in disengaging the catches is overcome by the eccentric, and that, if the governor be applied to Sickels', the friction would have to be overcome by the governor. I will ask you whether, in both the plaintiffs' and defend- 1103 ants, the force required to disengage the catches is not to be overcome entirely by the eccentric, in operating the valve-gear?

A. It would not in the plaintiffs', unless through the application of a sector similar to that in the model which we had before us at that time. If the governor be attached to the sliding-piece or wedge, the governor would have to resist the tendency which the force of the valve in rising 1104 would apply to it, and consequently would receive the same force which the eccentric exerts in opening the valve, with a sector or inclined plane attached; which, not being a part of Sickels' arrangement, it was not considered as belonging to it. The circumstances are more nearly similar. The eccentric must exert the force necessary to open or disconnect the valves. The governor is incapable of doing it

1105 properly. The governor acts most perfectly when under no resistance whatever. It bears no restraint; for, any force exerted upon the sliding piece of the governor will operate to change the position of the balls, and consequently to affect the apparatus which it is intended to move; and that apparatus, applied to the governor, will be the best which acts with least force, or during the shortest period.

Q. My question had reference to applying the governor to the sliding piece, either by means of this sector, or by
1106 means of a slide like the wedge-slide upon the defendants'. When the governor is applied in that way to Sickels', will not, in both Sickels' and in the defendants', the power required to disengage the valve be exerted through the eccentric alone?

A. That would depend upon two circumstances.

Q. I wish you to answer my question, and then give any explanation you choose. I am speaking now of the governor applied to the adjustable piece in Sickels' precisely as it is applied by the wedge-rod, operated by the governor,
1107 in the defendants'; and I want to know whether, under that arrangement, the power to disengage the valves will not be applied wholly by the valve-gear deriving power from the eccentric?

A. The circumstances in other respects being the same, it will be the same.

Q. That last answer needs another question. Will not the circumstances be the same in both, under that arrangement?

A. To describe the circumstances which would render them dissimilar, it is necessary that I should refer to one
1108 peculiarity, which on Friday was remarked upon at some length, which is the comparative force required to lift these valves.

Q. I am asking you whether the circumstances in the two machines will not be the same, so far as regards the disengagement of the catches by the power derived from the eccentric. I am not asking as to the difference between the power required for the two.

A. Then I suppose it would be the same.

1109 Q. If you want to make any remark upon the testimony on Friday, I do not wish to prevent you.

A. In regard to the power required to move a slide-valve and puppet-valve, I suppose I misapprehended the question. The question was asked whether the lifting of a puppet-valve one-eighth of an inch would not give an equal area to the sliding valve lifted one-eighth of an inch. I did not apprehend that it had any reference to the absolute opening produced by a lift of an eighth of an inch. I suppose,

now, that it had relation to that, and I wish to correct the answer, if it did so, by stating that a conical valve, lifted an eighth of an inch, will not open as large an area as the sliding of a valve upon a plane, because, from the conical form of the valve, although it be lifted one-eighth of an inch, it is not removed from its seat one-eighth of an inch. The piston in a cylinder, when lifted, is not raised from its seat at all. A disc lifted perpendicularly to a flat surface, will be raised from its seat as much as it is lifted. If it be conical, it has a form intermediate between the cylinder and the horizontal disc, and the opening will, therefore, be somewhat in proportion to the shape of the cone. I suppose I did not apprehend the question then asked, from the fact that a reference to the circumference of a valve, and the length of the opening was not required, which would be necessary in order to answer directly whether the area would be equal in the one and the other. 1110

1111

Q. Did I misunderstand you when you stated that puppet-valves admit the steam to the cylinder with sufficient city at the time of starting the piston?

A. They usually do.

Q. It was merely with reference to that that I examined you with respect to the relative area of the ports—to establish that one fact. Now, sir, if there be any difference in the amount of power required to disengage the valves in the defendants' and in the plaintiffs', as I have supposed it, with a slide or a sector connected with the governor, will not that difference be immaterial, in view of its being derived from the eccentric? 1112

A. No, sir; the less power required to disengage, the less time may be required to perform it; if the valves of the defendants' machine be moved with less force than ordinary slide-valves, or ordinary puppet-valves, the motion may be performed quicker, and therefore will be accomplished in a less space of time; and while the governor is in contact—while it is acting upon the fulcrum, or upon the catch, it will be controlled in a measure, and the less time it is under that influence the better. 1113

Q. Then, sir, as you have had time for reflection since Friday,—at the time of disengaging the valve in the defendants' and in the plaintiffs', taking two engines of equal power, of equal capacity, and working at equal velocity, which will have the greatest amount of pressure upon the catch—the plaintiffs' or defendants'? 1114

A. I suppose the power required to be the same.

Q. In view of its being the same, is there any necessity for the catches taking greater hold in the one than in the other?

A. I think not.

1115 Q. Now, sir, whether you effect the disengagement by means of a wedge or a lever, in view of the power being the same in the two, cannot the one be effected in as short a period of time as the other?

A. I think not.

Q. I would like to have your judgment upon that point.

A. We suppose the power of the eccentric to be unlimited for that purpose. The wrist-plate, as a medium of transmission, may be made to move the lever with more velocity than *that* portion of the machinery, namely, the lifter. If it have more velocity, it will disengage sooner. If
1116 it have more scope in its motion than the lifter has in the operation, it will move sooner, move quicker, and, though it have to exert a greater stress at some points, yet, having sufficient power to disconnect with a greater velocity, it does act in a shorter space of time, and therefore will be better, so far as the governor is concerned.

Q. You have not answered my question yet. When a given weight is to be moved to a given distance, cannot it be done in an equal space of time by the wedge and by the lever?

1117 A. Yes, sir.

Q. Well, then, where will be the difference in using the one or the other?

A. As I said, it will arise from the capability of the motion of the wrist-plate, as it will have a greater scope, and therefore may be made to give a greater velocity to that part which disengages, than the valve-rod is capable of giving, inasmuch as it is limited to the lift of the valve.

Q. Now, sir, taking the defendants' and the plaintiffs' models as examples, which has the greater capability for
1118 disengaging?

A. The defendants' seems to have the greatest capability of rapid disengagement.

Q. Does not the catch take as much hold in the one as in the other?

A. It may the same.

Q. Now, then, assuming that it does take hold the same, cannot you give as great a proportion to the inclination of the wedge as you do to the arms of the lever, to effect that disengagement in the same space of time?

1119 A. You would be limited by the distance which the valve lifts—that being the entire scope of the motion; in the other, you are not thus limited; increasing the size of your wrist-plate indefinitely, your motion would have a velocity in proportion to that enlargement.

Q. Cannot you enlarge the inclination of the wedge in the same proportion?

A. It would be difficult.

Q. Why so? 1120

A. If it were greatly extended, it would present an obstruction, and increase the force upon the sector.

Q. Now, sir, what is the extent of the depth of the notch required, for an engine of the capacity of the defendants', to latch the valve?

A. I do not think it essential that any fixed depth should be had.

Q. Now, Mr. Stillman, as a practical question, would the difference in this capacity to disengage, upon the defendants' and the plaintiffs' plan, be a material difference? 1121

A. I think not very essential.

Q. Now, sir, is not the force depending upon the catch to be disengaged in the defendants' greater than it is in the plaintiffs'?

A. I should think not.

Q. The disengagement always takes place in both after the valve has been lifted—does it not?

A. Yes.

Q. You have testified that the power to work a puppet-valve is less, in practice, than the power required to work rotating or slide-valves—have you not? 1122

A. That answer related to the ordinary kinds of slide-valves alluded to by the counsel.

Q. So far as regards the power for working the valves, will it be any less in the defendants' valves than in ordinary slide-valves?

A. I think so, very much.

Q. For what reason?

A. The ordinary slide-valve covers all the port, and has a constant pressure upon it—very little mitigation of the pressure under any circumstances; in the defendants', the 1123 moment the valve is removed from its seat, it is entirely separated from any pressure upon it—as much so as in the puppet-valves, they being disconnected from the exhaust valves.

Q. Are not the puppet-valves balanced?

A. They are very nearly balanced.

Q. After the valve is opened, do you have anything more than the weight of the valve depending upon the catch?

A. The valve and its appendages.

Q. Does not the weight which was employed for closing 1124 the valve in the defendants', and its appendages, hang upon the catch after the valve is opened?

A. Yes.

Q. Now, sir, will you testify that that weight in the defendants' is less than the weight of the valve and its appendages in the plaintiffs'?

1125 A. I suppose them to be equal; I know nothing of their actual weight.

Q. Supposing them to be equal, is there not depending upon the catch, at the time, not only this weight, but the power necessary to move the valves notwithstanding they are opened?

A. It requires no power, comparatively, to move the valves, as there is no pressure upon them at the time of being opened; the pressure upon the valve is no circumstance.

1126 Q. Now, sir, turning your attention to this weight here, (defendants' plunger,) I will ask you whether, in a twenty-horse-power engine working with puppet-valves, the weight of the valves is equal to that weight?

A. They may not be so heavy as that weight, but will not vary much from it.

Q. Then, sir, I will ask you whether there are not a greater number of journals and joints in the defendants', the friction of which must be overcome, in working the valve, presenting a greater amount of friction than is pre-
1127 sented by the plaintiffs'?

A. I think not.

Q. There are stuffing-boxes in both, are there not?

A. Yes.

Q. Are there journals in the defendants' that you do not find in the plaintiffs'?

A. There is no material difference in that respect, I should judge.

Q. Then it is your judgment that the difference is not material between the two?

1128 A. In respect to the friction.

Q. Now, sir, as to the time the governor will be undisturbed and free to act in the two—in the defendants' and in the plaintiffs'—would not the governor be held during the time of disengagement?

A. Yes, sir.

Q. Is there any necessity for having the time of the disengagement greater in one than in the other?

A. I suppose both may be sufficiently rapid for practical purposes.

Q. Now, sir, you testified on Friday that the purpose of
1129 the two inventions is different in kind and not in degree—do not both cut off steam with a view to economise fuel?

A. Yes, sir, they do.

Q. Do not both, so far as they go, govern the power of the engine, by shifting the point of cut-off?

A. I stated on Friday that the application of the governor was for equalizing the motion; there is nothing in Mr. Sickels' arrangement that tends to equalize the motion.

Q. If the engine is going too fast when cutting off at 1130
half stroke, and you shift the sliding-piece in Sickels' to make it cut off at one-quarter stroke, will it not change the speed of the engine?

A. It will.

Q. Then do you not find in Sickels' a means of regulating the motion of the engine?

A. Only by hand.

Q. Is that a difference in kind or a difference in degree?

A. It seems not to be intended in the arrangement, for the purpose of regulating.

Q. Is not the arrangement a means of regulating? 1131

A. It is not generally so used, to my knowledge.

Q. How many engines working on that plan have you had under your control?

A. Two or three.

Q. Now, sir, on board of a steamboat, when you want to increase the speed of your boat, do you not shift the adjustable piece, so as to make it cut off long?

A. We sometimes do.

Q. Is that not a means of regulating the speed?

A. That is one means.

Q. Do you not shift it, then, for the purpose of increas- 1132
ing the speed?

A. We more generally use a throttle-valve for those purposes.

Q. When you have a cut-off of that sort?

A. Yes, sir.

Q. On steamboat engines?

A. Yes.

Q. Is it not better, sir, to do it by means of a cut-off valve?

A. I think it would be better. We have generally urged 1133
it upon engineers.

Q. As an engineer, having the capacity to regulate the speed of the engine by shifting the cut-off, as well as by shilfting the throttle-valve, would you feel justified in using the throttle-valve instead of the cut-off?

A. We are required to use the throttle-valve. There are circumstances existing in steamboats where the one would not be sufficient.

Q. As a means of increasing or decreasing the speed? 1134

A. In decreasing the speed—protracting a voyage, or suiting the motion of the vessel to the quantity of the coal on hand, we should advise the shortening of the cut-off.

Q. And yet you state that that is not a means of regulating the speed?

A. I say it is a means of regulating the speed by hand, but it is not automatic, and is not suited for manufacturing purposes, where more equal motion is necessary.

Dillmann Jr

1135 Q. Now, then, sir, having this as a means of cutting off, would there have been any more difficulty in contriving the addition of the governor, either with this sector or a sliding wedge to the Sickels' arrangement, than to contrive an entirely new valve-gear?

A. It requires the same kind of ingenuity.

Q. Well, sir, assuming that the addition had been made to Sickels', would that have been an improvement added to his cut-off, embodying his arrangement for cutting off, or would it have been an entirely independent invention?

1136 A. It would have been an independent invention, superadded to the other.

Q. But involving a cut-off?

A. A cut-off would be made use of, as it is in various forms of cut-off.

Q. When the throttle-valve was first applied, was it not governed by hand—set and regulated by hand?

A. Yes, sir.

Q. When the governor was added to that, was it an invention superadded to that?

1137 A. I suppose it would have been.

Q. Still involving, however, the use of the throttle, and its connection with the engine?

A. Yes.

Q. And the change of the governor to Sickels' would be a change of that kind?

A. Yes.

Q. I will ask you one thing in relation to the defendants' engine: Have you observed the descent of the weight
1138 in the engine? Does not the weight continue to move down a distance after it has been checked?

A. Yes, sir.

Q. The valve, I understand you to state, closes the port before the weight is checked?

A. Yes, sir, before it is stopped.

Q. Then must not the weight, in view of the fact that the valve is closed before the weight is checked, and that it continues to move after the weight is checked—must not that weight be sufficient to move the valve when closed?

A. Yes, sir; that, with the momentum of the parts, must
1139 be sufficient.

Q. Is not the momentum nearly arrested before it makes its final descent?

A. The movement of the valve is very slight after the opening is closed.

Q. Still, it is moved after the weight has been checked in its descent?

A. No, sir, it is not in any case that I have seen. The eccentric in the engine of Messrs. Youngs & Cutter does,

as now arranged, move the weight downward after its own 1140
force has brought it to rest.

Q. Then you think it is the momentum and not the weight that continues to move the valve?

A. Showing that the momentum of the weight and of the parts were not sufficient to bring the valve to the point to which it must necessarily come to give proper scope of motion to the eccentric-rod.

Q. Have you seen the engine working on Corliss' plan,
at the Rolling Mill in 22d street? 1141

A. No, sir.

Q. Now, sir, I will call your attention to the elements of this combination. You stated, in enumerating the elements of the invention, that there was no stem connected with the defendants' valve, and that the stem in the puppet-valve is indispensable as a guide. Now, sir, are not puppet-valves very frequently made with wings, for the purpose of guiding the valve to its seat?

A. They are frequently so used in pumps.

Q. Have they not been so used at times in steam-engines? 1142

A. Not to my knowledge.

Q. In the Western boat-engines is it not common to connect a stem at the top with a ball and socket, as in this sketch (handing a drawing)?

A. Yes, sir, I have seen them in that way.

Q. Does the upper stem in *that* arrangement answer the purpose of a guide?

A. The lower stem, in that case, is a guide.

Q. Is not that ball and socket connection adopted in
those engines for the purpose of giving the valve a little
freedom, that it may adapt itself to its conical seat, and 1143
avoid binding?

A. It might have that effect where the machine was not accurately fitted up.

Q. Now, sir, there is a wing in the defendants' engine, on the shaft, which fits into the groove in the valve. Does not that control and guide the valve in its motion?

A. That gives motion to the rock-shaft.

Q. Could it be moved by the rock-shaft, unless there
were some connection between the rock-shaft and the valve? 1144

A. It could not.

Q. Is it not the leading purpose of the stem of the puppet-valve, to form the connection between the valve and the mechanism which is to operate it?

A. Both offices I consider necessary, in the application to the puppet-valve.

Q. Well, sir, is it not the purpose of the stem—its chief purpose—to form a connection with the mechanism which is to operate upon it?

Stillman P

1145 A. In this case, it has nothing to do it.

Q. How can you communicate motion to the valve unless there be a projection from it passing out of the steam-chest to the mechanism outside?

A. This drawing, (of Watt's,) supposes the connection to be inside.

Q. Is the valve-gear of any engine inside of the steam-chest?

A. It is, sometimes.

Q. All the connections of the mechanism, down to the eccentric?

1146 A. In this, much of the mechanism is inside of the steam-chest.

Q. Now, sir, take the stem of the valve, as in this apparatus from the DeLaine mills. Is not the leading and essential purpose of that stem to form a connection with the mechanism which is to operate the valve?

A. That is an essential property of it.

Q. Is it not the chief purpose of it?

A. Unless there be a guide of that kind attached to the valve, it would be insufficient.

1147 Q. Could you, by any possibility, work the valve in *that* arrangement without such a connection with the mechanism outside?

A. You could not.

Q. Is it not the chief purpose of the rocking-shaft in the defendants', to form a connection between the valve in the valve-chest and the mechanism outside?

A. It is.

Q. Then, so far as regards the communication of motion to the valve, is not that shaft the equivalent of the valve-

1148 stem in the plaintiffs'

A. No, sir, not exactly. It is more than an equivalent. It serves as a rock-shaft.

Q. I mean, so far as it goes, is it not an equivalent for the means of communicating motion?

A. It communicates motion the same, so far as the valve-rod will communicate motion.

Q. Now, sir, would it destroy the substantial identity of

1149 Sickels' combination, to connect the stem of the valve with a rock-shaft, and to connect that rock-shaft by catches with the lifter?

A. I do not know that it would. This (Watt's model) will show how it can be done.

Q. As in this case, (defendants' model,) a lifter connecting with this arm?

A. There is nothing peculiar in the defendants' machine, in that respect, because slide-valves always move by a connection formed by introducing the rock-shaft through the

steam-chest, and so make it communicate motion to the 1150
valve. It is a well-known device.

Q. Cannot the puppet-valves in Sickels' arrangement be operated for the purpose of opening the valves, and tripping them to close the ports, by an arrangement of catches, hook-rods and wrist-plates, such as is represented in the defendants' model?

A. I suppose they might be.

Q. Could not the defendants' valves be operated for the purpose of opening them and tripping them, by means of
the lifters, substantially such as are intimated in Sickels' 1151
patent?

A. They could be lifted, but not so appropriately to the action of that cut-off.

Q. Now, sir, if the sole purpose of the defendants' had been to open the valve, and disconnect it from the mechanism which opens it, at any desired point of the stroke, could not the same thing have been accomplished by moving these hook-rods in a straight line from a rock-shaft, instead of the wrist-plate, and putting a wedge upon the surface of the rod, to be brought in contact with the adjustable stop,
to effect the disconnection and re-connection? 1152

A. It could have been done, but not so well.

Substantial identity

Q. Now, sir, I understood you to state that the defendants' was substantially different from the plaintiffs', because, among other things, Sickels' arrangement could cut off, beyond half-stroke, and the defendants' could not?

A. There is that difference between the two apparatus.

Q. Do you know whether the defendants' can be so modified as to regulate the cut-off beyond half-stroke, as well as within half-stroke?

A. I do not know that it can. 1153

Q. If it could, by an addition or alteration, be made to cut-off beyond half-stroke, as well as within half-stroke, would that destroy the substantial identity of his arrangement, all the rest being retained as it is?

A. It would depend upon the apparatus—the extent or kind of the apparatus required to make them identical in their operation as well as in form. I do not know that I can answer that question.

Q. I am assuming that the thing may be done without 1154
alteration of his arrangement, but by an addition to his arrangement. Would such addition to the arrangement destroy the substantial identity of his arrangement?

A. I cannot answer such a supposition, because I cannot trace it in my mind to any definite point.

Q. If a person used Sickels' arrangement and never reversed the adjustable piece so as to regulate beyond the

Sleeman F

1155 half-stroke, would he be using substantially Sickels' invention, or a different invention?

A. I understand when the sector is applied, that it relates to the half-stroke.

Q. Taking the sector off, and having the regulating screw, and the party never to use it beyond half-stroke, would he be using Sickels' invention, or a substantially different invention?

A. I think I do not apprehend your question.

Q. Assume it to be constructed precisely like Sickels'
1156 construction, but the user not employing it for the purpose of cutting off beyond half-stroke, but limiting himself in the use of the apparatus to cut off within the half-stroke—making it so that it cannot be reversed?

A. That apparatus cannot change the sliding piece, so as to cut-off beyond half-stroke, without material alteration in it; I supposed the sector applied to Sickels' plan, as cutting-off within half-stroke, and therefore admitted them to be equivalent in that respect. The sector, in order to give the full scope of Mr. Sickels' claim, in regard to the
1157 point of cut-off, would have to let go of the sliding-piece, turn it over, reverse it, and replace it, which it cannot do.

Q. Now, sir, for the mere purpose of engaging and disengaging the valve from the mechanism which operates it, is not the hook-rod, with its spring, the equivalent of the lifter-rod in Sickels' arrangement, with its spring-catch, for the mere purpose of engaging and disengaging?

A. Any piece of an apparatus may be equivalent, or may not be equivalent. If performing some other office than the one named, it would not be equivalent. If it perform-
1158 ed it in some better manner—some qualified manner—it would not be an equivalent.

Q. Does that perform any office in the combination which is not performed by the lifter with its spring-catch in Sickels'?

A. I think it does.

Q. What is it?

A. It partakes of a motion from the wrist-plate, being connected with that portion of the circle which moves in a different direction to effect a more rapid motion, and may
1159 be thereby effective in a different degree, so as to destroy its identity.

Q. Does it perform any other office than that of connecting the valve-gear with the valve, for the purpose of opening the valve, and disengaging it, to permit the valve to be closed by a weight?

A. That rod—

Q. Cannot you answer my question; does it perform any other office than that of engaging the valve for the purpose

of opening it, and disengaging it to permit it to be closed 1160
by a weight?

A. I understand it to be a means of lifting the valve-gear, as well as engaging or disengaging it.

Q. Is not that the purpose of the lifter and the catch in Sickels' arrangement?

A. They do not appear to be identical in their arrangement.

dashpot

Q. I am speaking now about the office which they per-
form; I am not speaking of their difference of form, be- 1161
cause everybody can see that with the eye.

A. The office performed is similar, if not identical.

Q. I understood you to state on Friday that the air dash-pot of the defendants' was analogous to Sickels', but essentially different; now, sir, how do you explain that expression—that two things are analogous, and yet substantially different?

A. If I said analogous, I meant in external appearance, to the eye of one not versed in the construction of the parts.

Q. Are not both for the purpose of permitting a weight 1162
to descend rapidly, and to check it towards the end of its fall?

A. No, sir, one is to check the motion of the weight, and the other of the valve alone, and, therefore, not technically considered a weight.

Q. Is not everything ponderable a weight?

A. An engine is a weight in that sense.

Q. If it falls, would it not fall as a weight?

A. It would not require a dash-pot to arrest it.

Q. I suppose not; if it fell it would be very apt to break;
I will repeat the question, and modify it to avoid that 1163
technicality; are not both intended for the purpose of permitting a body to descend rapidly by the force of gravity, and to check the descent of that body towards the end of its motion?

A. I suppose in such a sense they are.

Q. Have you any doubt about the answer to that question?

A. Oh, no.

Q. In both, is there not a plunger fitted to work in a ves- 1164
sel containing a fluid?

A. Yes.

Q. In both, is not the plunger permitted at first to descend freely, by reason of the free discharge of a fluid from below the plunger, and then checked towards the end of the fall, by reason of the plunger, in its descent, gradually closing the escape aperture and thereby confining the fluid?

Stillman P.

1165 A. Not necessarily.

Q. Are they not so; I am not asking about the necessity for it; are they not so in fact?

A. In the dash-pot we have here——

Q. Answer my question; I am not examining you with reference to things that have been made since; I am asking you with reference to things as used by the defendants.

A. I understand that to be in use. I have seen it in use.

Q. We are speaking now about the air dash-pot heretofore used by the defendants, and constructed like *this* (brass model) with a hole in the side, which the plunger passes
1166 in descending?

A. Such is the case with one form of dash-pot I have seen used. It is not the case with another form that I have seen used.

Q. But that form heretofore used by the defendants?

A. I do not know to what extent they have used that form.

Q. Confine your answer in reference to this model—taking *that* as an example of the defendants'?

A. With that model in view, I should answer in the af-
1167 firmative.

Q. Where, then, is the substantial difference between the defendants' and the plaintiffs'?

A. It is in the office which it performs, the part of the machinery which it arrests, and the manner in which it arrests it. There is no secondary chamber necessary in the one case. Its design is to present a cushion or a falling weight, and not to re-supply itself by a secondary chamber, as in the plaintiffs' machine. It is therefore substantially different in character.

1168 Q. Now, sir, if you put this dash-pot of the defendants in a vessel of water, and you make that aperture larger, in proportion to the difference between the density of the fluids employed—between water and air—would that operate substantially like or substantially different from Sickels'.

A. It would not operate so well as with air.

Q. I am asking you whether it would operate substan-
1169 tially like or substantially different from Sickels'?

A. Substantially the same—the proportions being suited to the difference in the mobility of water and air.

Q. What do you understand by the secondary reservoir or chamber of Sickels' arrangement? Is it not that part of the apparatus in which the fluid is confined by the plunger, towards the end of its motion?

A. Yes, sir.

Q. What do you call that portion of the defendants' apparatus below the hole through which the fluid escapes? Is

not that the secondary chamber, in which fluid is confined 1170
by the descending weight?

A. I consider that the primary chamber; that is the only one which is of any value in arresting the weight.

Q. Now, sir, is the upper part of Sickels' dash-pot for any other purpose than that of a reservoir to contain fluid?

A. I suppose not.

Q. If you cut away all the upper part of Sickels' arrangement, leaving merely suitable guides, and place that in a vessel of water, would it not work just as well as in the form
described in his patent? 1171

A. Any reservoir would be a secondary reservoir.

Q. Just answer my question. Taking the upper part of the cylinder and cutting it all away, and placing that in a pail of water, would it not operate just as well, on the same mechanical principle, that it would as described in the patent?

A. Precisely the same; the pail of water would supply the place of the reservoir which was cut away.

Q. Does not the surrounding atmosphere present a secondary reservoir, to supply the defendants' with air?

A. In the same sense that the ocean would supply a third 1172
reservoir in Sickels' arrangement.

Q. Does it not constitute a reservoir, supplying the air which is to be confined in the cup or secondary reservoir of Corliss' arrangement?

A. Certainly.

Q. Now, sir, if you take Sickels' dash-pot, just as described in his patent, and substitute it on the defendants' engine for his air dash-pot, would it not govern and control the descent of the weight as effectually as the air dash-pot?

A. I do not think it would. 1173

Q. Why not?

A. Water, for all practical purposes, is non-elastic, and more easily controlled and regulated, while the air dash-pot, when applied to puppet-valves, would not be so efficient or proper, from that difference.

Q. Would it not permit the weight to descend with the rapidity required for the closing of the valve, and check its descent, so as to prevent the valve from slamming, just as effectually as the air dash-pot used by the defendants?

A. I suppose it would. 1174

Q. If you substitute air for water in Sickels' dash-pot, and give it the required proportion, would it not prevent the slamming of the valve?

A. I think it would increase the slam of the valve; the elasticity of air in that case would cause a tremulous motion of the valve upon its seat, which, with puppet-valves, would be ina dmissible.

1175 Q. Have you ever seen it tried?

A. I know from the nature of air—its elastic character—that it would be likely to do that.

Q. If you give it capacity enough?

A. I do not know that capacity, within any reasonable limit, could be given, to change that result.

Q. You do not know that it has ever been used with air in connection with puppet-valves?

A. Not successfully.

Q. Do you know if it has been used?

1176 A. I do not know that it has been successfully used.

Q. Does the elasticity of air, in the defendants' arrangement, subserve any purpose which would not be subserved by water, as a means of arresting a falling weight?

A. It is better, and, on another account, that it is always on hand to supply itself.

Q. Answer my question; does it subserve any purpose in arresting the weight which would not be subserved by the use of water?

A. I suppose Mr. Sickels' dash-pot would answer the
1177 same purpose as well in that respect as in arresting the valve.

Q. Now, sir, would the character of a pump be entirely changed because you pump air with it instead of water?

A. Its proportions would be changed.

Q. Would the character of the pump be essentially changed by applying it to pump air instead of pumping water?

A. It is a pump in both cases, as far as that term is con-
1178 cerned; essentially it would be the same.

Q. Now, sir, as a means of arresting a body, does not water act as a spring?

A. Practically it does not.

Q. Now, sir, if I take a body and place it upon a body of water, and force it down, does it not elevate all the surrounding water, and in that way, by the mobility of the particles, have a spring-like action?

A. No, sir, it is not a spring at all.

Q. What is it that makes a fisherman's bob bob up and down in the water; is it not the spring-like action of the
1179 water?

A. No, sir; to have any spring-like action, it must result from the line or the body itself.

Q. When you act upon any given surface of water, do you not communicate motion to all the surrounding particles, and change their places by the force of gravity, and does not the tendency of the particles to resume their original position become spring-like?

A. It would act by gravity.

Q. Do you know if it is necessary, in Sickels' cut-off, to adjust the pot, or secondary reservoir, as it is called, to any change in the range of the cut-off; for instance, when you cut-off short, from cutting-off long, is it necessary to do that? 1180

A. We used to consider it necessary.

Q. Is it necessary in practice?

A. I do not know that we have practised it lately.

Q. When you went the voyage from New York to Washington, in the *Baltic*, did you not have occasion to see whether, during that trip, they had to adjust the cup every time they adjusted the cut-off? 1181

A. I did not see it done.

Q. Did you think it necessary to do it—the cup being once properly adjusted to the parts?

A. If the cup were large enough, I should think it would not be necessary to change it—the water remaining properly in its place.

Q. Now, sir, with reference to slamming; in both the plaintiffs' and defendants' arrangements, is not the valve closed by the gravity of the falling weight? 1182

A. In the defendants' it is closed by the gravity of the falling weight.

Q. Now, sir, if the falling weight which is exerted upon the valve be not itself checked, must it not be necessary to apply some check to the valve itself, to stop it at the right place?

A. It might.

Q. If you do not stop the weight, must you not put a stop for the valve to strike against?

A. In the operation of the machine which I have seen, 1183
if they always act uniformly in that manner, it would not be necessary, because there the valve was arrested by the friction produced by the pressure upon it.

Q. You are travelling out of my question; if the weight itself be not arrested, but continues to exert its force upon the valve, would it not carry the valve beyond the point required?

A. It might not be sufficient to carry it beyond the point required, as I think it was not sufficient when I saw the machine of the defendants in operation.

Q. Did you ever see the defendants' machine in oper- 1184
ation, with the connections *down here* entirely cut away, so that the weight would have a chance to continue to fall?

A. No, sir.

Q. Suppose a case of that sort?

A. I suppose, then, that the action would be very uncertain.

1185 Q. Would it not be necessary to introduce a stop for the valve to but against, to stop it at its right place?

A. It would; you must have a stop somewhere.

Q. If you put it upon the valve itself, would the valve not slam against that stop?

A. I suppose it would.

Q. Then, sir, in both plans, is it not necessary to regulate the closing of the valve, and to prevent, by checking, the descent of the weight which closes the valve; is not that necessary, in both, to check the descent of the weight by
1186 which the valve is closed?

A. I suppose it to be necessary to arrest it somewhere.

Q. Now, then, sir, in both engines, is not a vessel, acting upon the fluid, which is confined towards the end of the operation, introduced for the purpose of checking that descent of the weight, and to prevent the consequences arising from the arresting of that weight?

A. The elasticity I understand to be for the purpose of preventing the sudden checking of the weight and the consequent concussion produced by one hard falling body impinging upon another hard body.

1187 Q. Now, sir, if you make a puppet-valve with so tight a packing around the stem that the valves will not fall of their own weight, would it not be necessary to close them, on Sickels' plan, by a superadded weight, to overcome that friction?

A. The proper way is to slack-up the stuffing-boxes.

Q. Suppose you make them tight, would it not be necessary to add a suspended weight for the purpose of overcoming that friction?

A. Yes.

Q. In that case, where you add a weight for the purpose
1188 of closing the valve, cannot the connection between the valve and that weight be made flexible by means of a chain, as in the example that you gave us of the defendants'?

A. I suppose it could.

Q. Would it not then be necessary to use the dash-pot, or some equivalent apparatus, to stop the slamming of that weight at the end of its motion?

A. That would depend upon whether the main dash-pot to arrest the valves was sufficient to retard and suspend
1189 both.

Q. I am supposing a case in which the valves are not weighty enough to overcome the friction, and that you suspended a weight to them sufficient to close them. When that weight descends, is it not necessary to interpose something to check its slamming?

A. In a puppet-valve the pressure of the steam increases

upon it as it comes near its seat. I never knew a valve to have so much friction from the stuffing-boxes as to be held when near its seat.

Q. I am supposing a case where the friction is sufficient to resist this. and that you supera :d a weight for the pur- 1190
pose of bringing them down.

A. A dead weight would be very improper in that case.

Q. I am not asking about the propriety; I have put a proposition that I want an answer to. In that case, could you not interpose a flexible connection between the weight which is employed to bring them down and the dash-pot—between that weight and the valves?

A. When the valves stick up, it is usual for the engineer to put his foot upon them and give them a start.

Q. I am not speaking about anything in actual practice; I am now meeting a point which has been raised upon the other side, not of practice, but of simple experiment. 1191

A. I am a practical man.

Q. I doubt whether you would construct an engine with those leather straps, if you could get a rigid rod.

A. I would rather have them, from what I have seen.

Q. Now, in every instance, is it not necessary that there should be, for practical purposes, a solid or firm connection between the plunger that is arrested in the dash-pot and the weight that operates the valve?

A. Am I to understand the weight which operates the valve to be the valve itself?

Q. I do not care where that weight is. Is it not neces- 1192
sary that there should be a rigid connection, in any arrangement that you have, between the dasher that is arrested by the fluid and the weight that operates the valve to close it?

A. If I understand rightly, the effect of an answer to this in the affirmative, would be to negative my previous answer in regard to a strap or rod in that arrangement.

Q. Is the whole of this (holding up a plunging weight) the plunger.

A. Yes.

Q. Is it not the lower part only that stops the hole? 1193

A. It is the lower face of it.

Q. Now, sir, is not this weight above added for the purpose of closing the valve?

A. As a weight, it is.

Q. Separate the lower face of that from the weight which is added simply for the purpose of closing the valve, and I want to know whether you could interpose a flexible connection between the plunger and the weight which is employed for closing the valve?

1194 A. I do not know what difference it would make, whether it were a shallow or deep one.

Q. I will suppose *this* to be cut away here, and *that* to be fitted to this cylinder, and then a chain connecting this plunger with this upper part of the weight, and this weight then to be connected to the valve-arm; I want to know whether that would operate in practice?

A. I should think not.

Q. Is it not because you must have a rigid connection between the plunger which is arrested by the dash-pot and
1195 the operating weight which closes the valve?

A. You could effect that result with a loose connection—chain-connection—provided you had a dash-pot to arrest each weight; and so, should you have a hundred weights, a hundred dash-pots would be necessary to arrest them.

Q. Take *this* arrangement. Does it change the character of this arrangement to have the dash-pot above instead of below?

A. Not when the parts remain the same.

Q. No matter what the parts are, but taking them as
1196 they are *here*, does it make a substantial change to have the dash-pot above or below?

A. No.

Q. If you have a dash-pot above, may you not interpose a flexible connection between the tripping apparatus and the valve?

A. Yes.

Q. And still effectually prevent the slam?

A. Yes.

Q. In other words, when you have an effective weight, (the weight which closes the valve) placed below the dash-
1197 pot, you may have the connection flexible; but when you have the dasher below the effective weight, must you not have a rigid connection?

A. In one case a rigid connection is necessary, and in the other I suppose it to be not necessary.

Q. Now, sir, in both cases, as a practical question, does not every vibration, every concussion which takes place in a piece of mechanism, injure that mechanism?

A. It is very apt to.

1198 Q. Is it not an object, in the construction of steam-engines, to avoid that concussion in every instance?

A. Yes, sir.

Q. When steam is suddenly let into the cylinder of a very large steam-engine, does it not produce a violent concussion, which is injurious to all parts of the engine?

A. It depends upon the point where it is let on.

Q. Is it not felt, if the valves be opened very suddenly?

Is it not a shock felt throughout the entire engine, more or 1199
less?

A. It makes some difference; but, where the steam is let on before the piston reaches the end of the cylinder, at the termination of its stroke, it tends to arrest the momentum and prevent the slam.

Q. I am speaking of starting the piston.

A. After the piston is started from its place, a sudden opening of the valve, if a large one, would tend to make a shock.

Q. Is not a shock produced in that way a serious injury 1200
to engines; and is it not your object to avoid it in constructing large steam-engines?

A. One of the objects in giving a lead to the valve before the termination of the stroke was for that purpose—to divide the force applied to the piston at different points of its motion.

Q. What is it that produces that peculiar tremulous motion that we see in the large shafts of steamboats? does it arise from the blows struck upon the shaft itself, or by the striking of the paddles on the water?

A. I suppose the apparent trembling of a boat is owing 1201
more to the striking of the paddles on the water than any other cause.

Q. In other words; can you strike a violent blow upon a piece of mechanism, without carrying the vibration through all its connections, and injuring all its connections proportionately?

A. It is a great annoyance, at any rate, whether it seriously impairs the parts or not.

Now, sir, does not the vibration of the axles of railroad
cars, due to the contact of the wheels with the rails, so dete- 1202
riorate them, that in course of time they cannot be trusted, and have to be thrown aside?

A. I suppose that to be the fact.

Q. You told us on Friday that one of the material differences that you noticed was, that in Sickels' the valve must be checked just before it is closed.

A. Yes, sir.

Q. While in the defendants' it is only checked after the port is closed?

A. Yes. 1203

Q. Did I understand you to say that that was a material difference?

A. Yes, I think that it is quite material.

Q. Is that upon the hypothesis that the quicker a valve is closed in cutting off the better?

A. Yes, the arresting of a valve in any measure before it closes its opening, the more the steam is wire-drawn, as it is called.

Stillman

1204 Q. Now, sir, about how far from the seat of the valve does the check take place in Sickels' arrangement?

A. I suppose it varies.

Q. As a general rule?

A. From one inch to a quarter. I think I have seen it perhaps more than an inch.

Q. Would that slight difference be very material in the working of an engine—in the power developed?

A. Slight in proportion to its time.

Q. I perceive from the publications, that the engines built in your establishment for the *Arctic* and *Pacific* have cut-offs which belong to "Allen & Wells?"

1205 A. Not to "Allen & Wells."

Q. The *Northerner* and *Southerner?*

A. No, sir.

Q. On which of the steam-engines is that used?

A. The original plan was built by Allen, and is used upon the *Arctic* and *Atlantic*. I think it was first applied to the *Northerner*.

Q. The *Cherokee* and *Tennessee*, and the *Franklin* and *Humboldt?*

A. Yes.

1206 Q. In that cut-off does the valve close as rapidly as it does in Sickels' arrangement?

A. I do not know but it does.

Q. Cannot you tell, as a constructor, whether it does or does not?

A. I have never measured the difference.

Q. Would you select a cut-off to put on board of a large steamer, without determining a point so material as that?

A. I should see that any plan descended with sufficient rapidity, and I should yield a portion of that rapidity if the apparatus were attended with other difficulties more mate-
1207 rial than that.

Q. If check-rings be used in connection with puppet-valves, will not the steam be cut off before it becomes necessary to check the valve?

A. It will be partially cut off.

Q. Will it not be substantially cut off?

A. It would be, perhaps, as perfectly cut off as Sickels' valve can cut off at the last part of the motion of the valve.

Q. Have not check-rings been frequently made steam-
1208 tight?

A. I never knew them to be made steam-tight. We never made them so. We have made none for the last ten years.

Q. Do you suppose that the amount of steam that would be lost by the leak, if you used check-rings, could be estimated?

A. Yes.

Q. Would it be worth taking into consideration? 1209

A. A check-ring must not be made tight; otherwise, they are equivalent to the valve remaining upon its seat. The object of a check-ring is to admit a little steam into the cylinder at the time of passing the centres, when the shock is felt, and then opening it wide, that the steam may be received without a shock.

Q. Was not that *Barber's* improvement upon the old check-ring, for which he obtained a patent? Do you not know what the old check-ring was, before *Barber* took out his patent to give them a little play? 1210

A. I do not know what you allude to.

Q. I mean the check-ring that was steam-tight, so as to admit of closing the valve, shutting off the steam more rapidly before the valve came to its seat, and giving the valve a motion before it opened its port.

A. We never used them in that way.

Q. You have testified that Sickels' arrangement would not instruct you in the construction of an engine like the defendants'. I will ask you whether Sickels' specification would not instruct you so far that the steam-valves are to 1211
be opened by mechanism deriving motion from the eccentric?

A. No, sir; we knew that before Sickels' plan was invented.

Q. Just wait until you get the whole of the question—that this mechanism is to be connected by a latch or catch with a rod, stem or other thing attached, to re-connect with the valve—that there is to be an adjustable stop, which, when set, will, at the required period in the stroke of the piston, disengage the latch or catch, and permit the valve 1212
to be rapidly closed by the force of gravity, whilst the mechanism in connection with the eccentric continues its motion and returns to be re-engaged by the latch, preparatory to another operation—and that the force of gravity, by which the valve is closed, to prevent violent and injurious concussion, is to be gently checked towards the end of the motion by a fluid which is gradually confined by a plunger which gradually closes an aperture?

A. So far as I understand the whole of the question, I should not be instructed by Mr. Sickels at all. I have seen it in operation substantially before his invention. 1213

Q. That is not the question that you were asked. We know your feeling as a witness here. Now, Mr. Stillman, has not your establishment, for the last 8 or 10 years, been engaged in trying to get up a cut-off apparatus that would avoid this patent?

A. No, sir; we have never tried to avoid the patent at all.

(*Mr. Seward* objected to this course of inquiry, as irrelevant. The Court sustained the objection.)

1214 Q. If you will answer my question, shutting your memory
to what you seem to have seen before these patents, and de-
riving your knowledge for the first time from this specifi-
cation, would it not instruct you in these things?
A. I cannot disengage myself from circumstances prac-
tically, to put myself in the position of answering a ques-
tion so broad as that.
Q. Then I will put it in detail. Do you not find in both
the plaintiffs' and defendants' that the valve is opened by a
mechanism deriving motion from the eccentric?
1215 A. Yes.
Q. And that that mechanism is connected with a valve
by means of a catch or latch, which, at a given time, is dis-
connected, that the valve may be closed by the force of
gravity?
A. Yes, sir.
Q. And that mechanism which affects the disengage-
ment is adjustable to determine the point when the valve
shall be liberated—an operative mechanism, continuing its
motion, and coming back to re-engage the valve? Do you
1216 not find in both that the descending weight which closes
the valve descends rapidly, and is checked towards the end
of its motion?
A. It is decidedly, under the restrictions and qualifications
of former answers to the same point.
Q. So far as regards these points, then, in your mind,
they do agree.
A. Generally.
Q. Now, sir; would the descriptions and drawings of an
English marine engine instruct you specifically in the con-
1217 struction of what is known as a North River boat engine?
A. It would not in all its parts.
Q. In this arrangement of Mr. Watt's, is not the motion
of the valve, whether the weight be employed to open or
close the valve,—is not the weight which operates upon the
valve connected with the valve by means of what is called
a toggle, which gradually, by its approach to the dead cen-
tre, arrests the motion of the moving parts?
A. I suppose it is.
Q. Would not that in itself operate as a check to the
1218 momentum of the moving parts, as a crank gradually ar-
rests the momentum of the moving parts of a steam engine
so as to avoid the shock?
A. Yes; that is the principle upon which our arrange-
ment acts.
Q. Now, Mr. Stillman, with reference to the valve gear:
Is the latch in this arrangment of Watt's employed to con-
nect the valve with the valve gear, that it may be opened
by the motion of the engine by such connection, or it is
simply a latch to hold the valve closed or open?

A. I have not studied that model sufficiently to tell critically. 1219

Q. Is the arrangement represented in that model substantially like or substantially different from the arrangement in the defendants'?

A. So far as the dash-pot is concerned, it is similar in form and effect.

Q. Similar in effect?

A. Yes.

Q. Do you not know that the dash-pot presents a constant resistance, from the moment the weight is liberated, to the end of its motion?

A. Yes, sir; and in that it differs. 1220

Q. If you were to apply to the defendants' a dash-pot that would present a constant resistance from the beginning to the end, would it answer the purpose contemplated in Sickels' arrangement?

A. No, sir.

Q. Would it answer the purpose of permitting the valve to be closed rapidly, and the weight to be checked at the end of its motion?

A. I suppose in this model it would depend upon the toggle.

Q. Independent of the toggle—I mean the dash-pot itself? 1221

A. It would receive a shock which the valve-seat would otherwise receive. In that it resembles the plaintiffs'.

On being *re-examined*, the witness, THOMAS B. STILLMAN, testified as follows:

Q. In an engine of twenty horse-power, of what diameter would you construct puppet-valves?

A. The size would differ in a high-pressure and a low-pressure engine, to some extent; probably four inches in diameter would be a reasonable size, where considerable steam is carried.

Q. For a high-pressure or a low-pressure engine?

A. Where considerable pressure of steam is carried. Where the steam is quite low, we would make them large. 1222

Q. What is the length of the slide in the defendants' engine?

A. I should judge about twelve inches.

Q. What is the length of the opening of the port?

A. About twelve inches in length.

Q. How far would a puppet-valve, in the ordinary mode of constructing a twenty horse-power engine be lifted from its seat in opening?

A. We usually lift them a little higher than is necessary to give the full area of the opening. Perhaps it may be two inches, but I do not precisely know.

1223 Q. What is the ordinary depth of the valve-seat in such an engine?

A. From one-half to three-quarters of an inch.

Q. You spoke of a mechanism for causing the valves to open more slowly in large steamers. What is the object of that?

Q. If the valve is made to open more slowly, it is to prevent any shock that may take place when a large valve is suddenly opened.

Q. What effect does it have upon the quantity of steam
1224 used?

A. It is not designed to have any effect upon the quantity of steam used.

Q. Does it use more or less?

A. It would be retarded so as to waste no steam by reason of any premature opening of the exhaust. We suppose the cylinder must be filled to the pressure of the fountain, and continue filled at that pressure until the point of cut-off. That is designed and desirable in the proper cutting off of all engines. There is generally no difficulty in admitting steam enough at the starting of the piston. At
1225 that time the space to be filled is very small. By admitting steam before the engine passes the centre, the steam will be compressed and form a cushion for the piston, but will not thereby be lost, unless it escapes through the exhaust valves, because that compression will by dilation resume its former elasticity, as the piston moves onward.

A. You have said that you did not use check-rings for the last ten years. Will you state the reason why?

A. We have found that altering the lead of the valves answers the purpose better, so as to separate the time of
1226 opening the exhaust to let out the steam, and make it earlier, and remove the shock which would result were the valves opened after the engine had passed the centre.

Q. You said there was a difference between the pressure upon the valves in Corliss' machine and the pressure upon ordinary slide-valves; will you state the amount of that difference in your judgment?

A. I have not estimated it, but I suppose it to be very considerable.

Q. Will you state why it is, in your opinion?

1227 A. *This*, (referring to a model,) is the ordinary form of an ordinary high-pressure slide-valve—a form sometimes used in low-pressure engines?

Q. Will you explain the operation of it.

(Witness explained on the model.)

Q. What is the difference between the operation of that valve and the defendants' valve?

A. In the defendants' the function of admitting steam 1228
and the exhaust are performed by separate valves. The steam-valve is relieved from pressure the moment it passes from the opening. I spoke of this the other day as passing steam on both sides of it. Some valves are so constructed. In this case, the valve covers the opening, and, when moved, allows the steam to pass into the opening. When the opening is clear, the valve is as free as *this* is, and requires no more force to move it. When the valve is brought over the opening, then the pressure of the steam acts upon it, and pressing it upon its seat produces friction. It is only at 1229
that instant that it is under pressure, and does not require the same force to move it. It acts more nearly as a balanced valve in that respect. As far as the cut-off is concerned it acts upon the steam-valve alone, and the accumulation of force necessary to operate both the steam and exhaust-valves will not affect the cut-off of the governor; therefore, it is much better adapted to engines to be worked by a governor, than a valve of this form, or of any form that moves with more difficulty. 1230

Q. What is the form ordinarily used in locomotive engines?

A. It is the form generally known as the short slide.

Q. What is the form used in the Cunard steamers?

A. That generally called the long slide, which is a slide the whole length of the cylinder, and operating somewhat differently, being packed from the outside to make it tight and hold it to its face or seat. We have nothing of the kind here; and it is difficult to explain without a model. In English steamers I have seen other kinds of valves used, 1231
such as the Seaward slide.

Q. In the model of Sickels' machine, during what portion of the operation of the spring is it in contact with the adjustable slide?

A. In that form it depends upon whether the slide is adjusted to cut off within half-stroke or beyond that point. If it cut off beyond half-stroke, then it is in contact sufficiently long to pass in the upward motion, and is in contact sufficiently long to disengage in the downward motion?

Q. Suppose you cut off in *this* arrangement at 1–8th of the stroke, so that the spring will pass beyond the adjustable 1232
piece, for how long a period of time will the spring be in contact with the inclines?

A. That closing, consisting, in this arrangement of a double action, would materially lengthen the point of contact with the slide. It is closed while the valve is ascending, but is in contact with the whole length of the inclined plane, and the governor will be arrested; and then, in descending again, it would also be arrested. This arrangement, there-

1233 fore, would more seriously affect the governor, and would not be a desirable arrangement for the governor, even if controlled by a sector; but to attach this sliding piece to a governor direct, as I have before remarked, would render it a practical nullity.

Q. In the arrangement in this apparatus from the De Laine mills, would the spring be in contact with the cam that liberates it after the detachment is effected?

A. I suppose it would.

Q. If this cam should be in any way connected with the
1234 governor, what would be the effect of the pressure of the spring upon it?

A. It would also affect the governor.

Q. Supposing, in this arrangement, steam to be cut off at 1–8th of the stroke, would the spring be in contact with and pressing upon this cam?

A. The pressure would be the same.

Q. What part of it would it press against while effecting a detachment?

A. I have not considered the proportions of it.

Q. We will take them from this model. Take *that* model and explain to the jury what effect the spring would have
1235 upon that slide, if it were in any way connected with the governor?

A. While the springs are in contact with the sliding piece it would act upon the governor, inasmuch as the sliding piece would be in contact with some portion of this movable sector. The governor, being attached to the sector, must be impeded or arrested during the time that such pressure was continued, and it would depend upon the length of time the springs were in contact with the sliding-piece, that the governor would have greater or less efficiency in its ordinary operation.

Q. After the detachment is effected in the defendants' machine, do you find any contact of any part upon the gov-
1236 ernor during the remainder of the stroke?

A. You find nothing after the valve is tripped.

Q. What is the object of all cut-offs?

A. The ultimate object is the saving of fuel.

Q. If the governor could be arranged in any way, so as to work the sector upon the model before you, would you consider the sector as an equivalent for the set-screw?

A. No, sir.

Q. Why not.

A. Because it is a part of the apparatus of the governor, if applied for that purpose. The set-screw and slide can be attached to the governor, as the governor can be attached to the sector.

On being further *cross-examined*, the witness, Thomas B. Stillman, testified as follows: 1237

Q. Is *that* a drawing of the Seaward valve (handing a drawing in *Lardner*, London edition of 1840, page 255)?

A. That is intended to represent it.

Q. As I understand you, the valves in this arrangement merely differ from those in being straight slides, instead of sliding on curved seats?

A. Yes.

Q. In the arrangement of Seaward's valves would the pressure be any greater upon the parts than in the defendants'? 1238

A. I cannot say that it would.

Q. I do not mean accurately, but generally?

A. There would be a similarity in the arrangement, producing similar results.

Q. Now, sir, in relation to this contact of the latches: When Sickels' stop is set to cut off anywhere within half-stroke, do I understand you to say that in returning again after disengagement, the contact of the latches with the wedges would interrupt the action of the governor?

A. No, sir.

Q. Now, look at the defendants' model, and just remark the time *that* is in contact there until it comes back again, (operating the machine—) I want to know whether in that arrangement the hook-rod, with the tension of the spring, is not in contact with the adjustable stop from the moment it begins to disengage the valve, until the hook-rod comes back to the point at which it first commenced to engage, and whether during the whole of that time it does not impede the freedom of the governor? 1239

A. Not during the whole time. I do not think it would amount to anything.

Q. Would not the contact of the hook-rod, with the tension of this spring, tend more to impede the freedom of the governor than the plaintiffs'? 1240

A. No, sir—very little, if at all.

Q. Would it not have some influence?

A. I do not know that it would practically.

Q. Would it not be more than no touch at all?

A. It is almost no touch at all.

Q. Is there not more than no touch at all—more than no contact there?

A. Except when in contact when they hook on.

Q. After the defendants' has disengaged, does not the hook-rod, with the tension of its spring, continue in contact with the stop, and to that extent bear upon the slide of the governor?

A. It may not be in contact. There is no necessity for its being in contact.

1241 Q. Must it not continue in contact during the whole of the time, until it comes back again, by reason of the very motion?

A. It may be in contact without absorbing sufficient power to materially affect the governor.

Q. But there is no such contact in Sickels', is there, after the disengagement takes place? After the disengagement takes place, and the moment it leaves the wedges, is not the governor perfectly free?

A. They do not bear upon the governor in any way.

Q. Has the rigidity of the spring anything to do with
1242 the governor, after it has passed the wedges?

A. In both cases it is alike.

Q. Is there any connection with the governor in any way after the disengagement has taken place?

A. There appears to be *there*.

Q. Is there not a contact there to a certain extent?

A. After disengagement takes place?

Q. To the extent of the tension of the spring-hook?

A. Whatever weight will be in this would be deducted from the pressure of that hook from which the governor is
1243 detached.

Q. But there is contact?

A. Yes.

[The witness stated, in answer to a question from Mr. *Jenckes*, that the mahogany model of the plaintiffs' apparatus, furnished by the defendants, and the black model were correct representations according to the specification and drawing attached to Sickels' patent.]

The defendants then called as a witness *William Clark*, who being sworn, testified as follows:

Q. What is your occupation?

A. A machinist.

Q. Where you do you work, sir?

1244 A. With Corliss, Nightingale & Co.

Q. Did you work upon this engine of Youngs & Cutter's?

A. Yes.

Q. What did you do?

A. I set it up.

Q. Have you ever set up any other engines of the same make?

A. Yes.

Q. How many?

A. Fifteen others; perhaps more.

Q. How many in this city?

A. Six.

Q. Did you make any marks upon this engine of the defendants', when you set it up? 1245

A. Yes.

Q. Where were those marks?

[The witness pointed out upon the plunger of the defendants' engine, marks, showing the points of the opening and closing of the valves.]

Q. Did you point out those marks to Mr. Hibbard and Mr. Bryant?

A. Yes, sir.

Q. In that engine, will you state whether or not the valve closes its port before or after the weight reaches the orifice in the air-cylinder? 1246

A. The valve is closed before the weight comes to the bottom, or before it comes to the opening that is in the bottom of the cylinder.

Q. What opening do you mean?

A. The opening at the side.

Q. How is it in other engines that you have set up of the same make?

A. It depends upon the size of the engine. If it were a large engine, the marks would be the same for the valves, but the weight would not come down so near the opening before the closing of the valve. If it is a large engine, you 1247
raise the weight higher.

Q. In this engine of Youngs & Cutter's, does the weight move after the valve has closed its port?

A. Yes.

Q. How far?

A. A little over ~~9-16ths, not quite 5-8ths of an inch.~~

Q. Have you seen the engine of the defendants' working without a rod attached to the weight?

A. Yes.

Q. What was put in place of the rod?

A. A string, or strap. I have seen it with a string and with a strap.

Q. How did it work with a string or strap? 1248

A. It seemed to work as well as with a rigid connection, if not a little better.

Q. Have you seen these parts of an engine before?

A. Yes.

Q. Where did they come from?

A. I think I have seen them at the Atlantic De Laine Mills, in Providence.

Q. What parts were these?

A. *That* was the steam-valve and dash-pot, as it is called, of Sickels' cut-off.

Q. Who took this engine down?

A. I do not know.

1249 Q. Were you present at the time it was taken down?

A. I was not present when *that* part of it was taken down.

Q. Do you know whether that was part of one of these engines?

A. I have seen that part there, and I saw it when it was carried out of there.

Q. Do you know who built that engine?

A. It was built by Thurston, Greene & Co.

Q. Will you look at that iron throttle over yonder, and state where that came from?

1250 A. That was used as a throttle-valve, and it came from the Atlantic De Laine Works, in Providence.

Q. Was it not part of this same engine?

A. Yes; I assisted to take that valve out.

Q. Will you look at the dash-pot and air-cylinder on the floor, and state where they came from?

A. *This* came from Youngs & Cutter's engine. It has been at work there two and a-half years, pretty nearly three years.

Q. What are the marks on that plunger, and what do
1251 they show?

A. Where the valve is upon the point of opening or closing. *There* is a mark when it is down at the bottom.

Mr. Blatchford.—It fills all that space after the valve is closed?

A. Yes.

Mr. Jenckes.—Will you state whether you have ever assisted in the construction of any engines operated with the old valve-gear of Watt?

A. Yes.

1252 Q. When, and where?

A. I have assisted to set them up and build them in Glasgow, in Scotland.

Q. How long ago?

A. About eighteen years ago, I guess.

Q. Have you ever seen Watt's valve-gear in use in this country?

A. Yes; at the Jersey City Water-Works.

Q. For what purpose is it used there?

A. For pumping water into the reservoir.

Q. Have you ever seen that valve-gear used for closing the valve by the weight?

A. I have seen it used for the closing of the valve with the plunger, and opening of the valve with a weight.

Q. By a strap.

A. Yes; generally hung by a strap.

On being *cross-examined*, the witness, William Clark, 1253
testified as follows:

Q. When did you see this engine at work in Jersey City?

A. I saw it last week, sometime. I heard of it before.

Q. How many strokes does it make per minute?

A. About $4\frac{1}{4}$, $4\frac{1}{2}$, and 5.

Q. How many strokes does the engine at Youngs & Cutter's make per minute?

A. I do not know. It ought to make 43. That is what it was calculated to do when it was put up. It may be going more or less now. Perhaps they have altered it.

Q. When the weight of Youngs & Cutter's falls that dis- 1254
tance of 1 inch and 1-16th, does it move the valve?

A. Yes.

Q. At that time, does it not move the valve very slowly?

A. Not very slowly.

Q. After the weight is checked, then it continues still to move down, and carry the valve with it?

A. Yes.

Q. Do you know if that weight is sufficient to move the valve when the valve is on its seat, after the port is closed?

A. Yes; more than sufficient, I should think.

Q. Where is what you call the "valve-stem" on Corliss' engine? Point it out on the model. 1255

A. Here, (pointing to the rock-shaft of the valve.)

Q. This rocking-shaft, as it is called?

A. Yes.

The Court then adjourned to January 9th, 1855, at 11 o'clock, A. M.

January 9th, 1855, 11 o'clock, A. M.

The counsel for the defendants put in evidence re-issued letters patent of the United States, granted to George H. Corliss, of Providence, Rhode Island, on the 13th of May, 1851, for 14 years from the 10th of March, 1849, for a new
and useful "improvement in cut-off ~~and working~~ the valves 1256
of steam-engines," (said letters patent having been so re-issued on an amended specification, on the surrender and cancellation of original letters patent granted to said Corliss, for the same improvements, on the 10th of March, 1849,) together with the schedule and drawings annexed to said re-issued letters patent, which schedule was as follows:—

1257 *The Schedule referred to in these Letters Patent, and making part of the same.*

To all to whom these presents shall come:

Be it known, that I, George H. Corliss, of the city and county of Providence, and State of Rhode Island, have invented certain new and useful improvements in steam-engines, and that the following is a full, clear and exact description of the principle, or character which distinguishes them from all other things before known, and of the manner of making, constructing and using the same, reference being had
1258 to the accompanying drawings, making part of this specification, in which fig. 1 is a side elevation of an engine on my improved plan; fig. 2, a longitudinal vertical section; fig. 3, an elevation of the valves, and the arrangement of parts working them; fig. 4, a plan thereof; fig. 5, a separate section representing a latch used in the valve-gear; figs. 6 and 7, a plan and section of an air cylinder and piston for checking the motion of the valve apparatus.

The same letters indicate like parts in all the figures. In
1259 that class of steam engines in which the steam and exhaust ports of the cylinder are opened and closed by slide-valves, whenever the valves close the ports, the steam presses them upon their seats with its whole force, and they cannot then be moved without the expenditure of a considerable amount of power; but when the valves do not completely close their ports, the steam pressing upon both sides of them, does not tend to hold them upon their seats, and at these times the valves can be moved with but a small exertion of force. When a valve has closed its port, its office is performed;
1260 and hence the force exerted in any further movement of it while the port remains closed, is wholly lost.

Now, it is customary in this class of engines to connect the valves rigidly, so that when one is moved, the other is forced to move with it to the same extent; the closed valve is therefore moved with the opening one, and consequently the whole amount of force consumed in moving it, while closed, is expended to no good purpose, and tends only to increase the wear and tear of the engine. To avoid this sacrifice of power, and, at the same time, to retain the advantages which result
1261 from the connection of the valves, is the object of the first part of my invention—which consists in moving each of the steam and exhaust valves of an engine independently by means of one crank wrist, of a series, which are all attached to a common disk, wrist-plate or other equivalent device, which is secured to and moved with a rock-shaft.

The several wrists which work the different valves, are arranged upon the wrist-place in such positions with respect to the rods and levers, or other devices which connect them with

the valves, that they shall act like so many cranks, each of which vibrates near its dead point or point of slowest throw, and therefore imparts but little movement to the valve it actuates when the latter is closed; while each moves with its fastest throw, and therefore communicates the greatest movement to its valve, when the latter is open. Two great advantages result from this method of working the valves; in the first place, much of the power heretofore expended in moving the closed valve, is saved; and, secondly, the wire-drawing of the steam is reduced, because the valves while opening and closing the ports, are moved with increased speed. 1262 1263

The second part of my invention relates to the method of regulating the cut-off of the steam in its passage into the engine; and consists in effecting this by means of the Governor which operates cams, so that when the velocity of the engine is too great, these cams shall be moved by the action of the regulator to such positions, that catches on the valve-rods may the sooner come in contact with them to liberate the valves, and admit of their being closed by the force of a weight or springs, and thus cut off the steam in proportion to the velocity of the engine; this being done sooner when the veloci- 1264
ty of the engine is to be reduced, and later when it is to be increased.

In the steam-engine represented in the accompanying drawings, the steam and exhaust valves *l*, *l*, and *m*, *m*, are situated in steam-chests *n*, *o*, at each extremity of the steam-cylinder; the chest *n*, at the top, is formed in the cylinder-head, while the other *o*, is let into a recess in the bed-plate. Each exhaust-valve *m*, is attached to one extremity of a valve-rod *p*, which is fitted at its opposite extremity with a sliding head *q*, that is linked by a connecting-rod *r*, to one arm *s*, of 1265
a bell-crank *t*. The other arm *v* of the bell-crank is connected by a rod with a wrist-pin *w* on the wrist-plate *x*. The latter is secured to a rock-shaft to which the requisite vibratory motion is imparted by an eccentric *a* through the intervention of an eccentric-rod and an arm *y* secured to the rock-shaft.

The wrists *w* of the two valves are in this example a quarter of a circle distant from each other, and the two connecting-rods extend in opposite directions from the rock- 1266
shaft,—hence, when one wrist is at its point of greatest throw, the other is at its dead point; and when one is imparting to its rod and the valve connected therewith, the greatest movement, the other is imparting to its valve the least. Each valve is therefore moved alternately fast and slow; and the fast movement of one is effected during the slow movement of the other; nearly the whole movement or throw of each valve being effected while the port is either partially or wholly open, at which time the least

Corliss valve 1849

1267 power is required to move it; while as the small remnant
of the throw when the port is closed, is effected during the
slow movement, but little power is then required, as the
distance to which the valve is moved, is now very short.
The steam valves, l, l, are worked in a manner similar to
that of the exhaust-valves, with the exception of an arrange-
ment by means of which they are made to close and cut
off the supply of steam at any required portion of the
stroke. The valve-rods b of these valves are double, and
instead of being permanently linked to their appropriate
1268 bell-cranks, are each connected by a detachable link h' with
a rack g', whose teeth engage with those of a tooth sector f'
on the bell crank. This detachable link h' is hinged at one
extremity to the cross-head c', which unites the two mem-
bers of the double valve-rod; it has a shoulder i' at its op-
posite extremity, which engages in a corresponding socket
on the rack, and is kept in place by a spring i''. This link
h' is also fitted near the rack with a projection j', which is
struck at the proper moment to detach the link from the
rack by a revolving helical cam k'. The helical cams which
1269 detach the links h' h' of the two steam valves l l, are both
secured to an upright shaft l', which is caused to revolve by
the movement of the crank-shaft, and is arranged at the
same time to move freely up or down in its boxes. This
shaft is connected at r' with the governor, (which in the
present instance is of the centrifugal variety, that being the
kind I have used, deeming it the best,) so that it shall move
up or down as the balls of the governor rise and fall.
When the governor balls s' s' are at their lowest position,
the shaft l' is depressed so far that the helical cams k' k' are
1270 below the range of the valve-link h' h', and consequently
cannot detach them; hence in this position of the governor
balls, the steam-valves, being connected with their wrist-
pins throughout the whole length of the stroke, are opened
and closed in the same manner as the exhaust-valves. As,
however, the velocity of the engine is increased, and the
governor balls rise under the increased centrifugal force,
the upright shaft l' is correspondingly raised, and the cams
being now revolved within the range of the valve-links,
strike the projections j' and detach the links h' from their
1271 racks.

The helical cams extend round the shaft in the same direction as the latter is turned, consequently the higher the shaft l' and its cams are raised, the sooner will the cams strike the projections and detach the links. As soon as the links are detached, the valves being entirely disconnected from the mechanism by means of whch they are opened, are consequently free to close. As the steam-valves in the steam-engine represented, move horizontally, they do not

tend to close by their own weight, and are consequently 1272
closed by means of weights o' o', which act through the intervention of bent levers, or bell cranks m', upon cross blocks n', secured to the respective valve-rods. In order to prevent the jar which would result from the sudden stoppage of the motion of the weight, each cross block n' has a cylindrical socket formed in the face nearer the steam cylinder, and a piston p' is secured to the engine frame, which enters the cylindrical socket and compresses the air within it to form an elastic cushion to prevent the jar. As the
racks g' are moved back by the action of the wrist-pins and 1273
the bell cranks, the shoulder of the link re-engages with the socket on the rack, so that the valve being now re-connected with the valve mechanism, is opened by the wrist-pin at the proper moment to admit steam into the cylinder. When the steam-valves are not used as variable cut-off-valves, they are to be operated in every particular like the exhaust-valves. It is obvious from the foregoing description, that when the valves are so arranged that they move
parallel with the axis of the cylinder, as is the customary 1274
arrangement in slide-valve engines, the rock-shaft by which they are operated, may with advantage be located in a position different from that described above, and the valve-connections must be adapted to this change.

A convenient mode of arranging the several parts when the valves move parallel with the axis of the cylinder, is represented at Fig's. 8 and 9, in which the letters indicate the parts corresponding with those indicated by them in the arrangement before described.

I wish it to be distinctly understood, that in the mode of
regulating the cut-off by the governor, I do not limit my- 1275
self to the use of the particular kind of cams described or represented; as the form, position and operation of these may be greatly varied without changing the principle of this part of my invention; as, for instance, stops or cams connected with the slide of the governor by levers, may be made to slide in the direction of the plane of motion of the valve-rods, to vary the periods of liberating the catches of the valve-rods; or wedge-formed stops or cams may be substituted for the helical cams and attached to the cam-rod,
which, in that case, must not turn. 1276

The mode of applying the principle which I have first described, is the one which I have essayed with success, and therefore I have described it minutely; but the two modifications indicated will show clearly that the same principle is susceptible of various modifications.

What I claim as my invention, and desire to secure by Letters Patent, is, first, the method substantially as described of operating the slide-valves of steam-engines, by

1277 connecting the valves that govern the ports at opposite ends of the cylinder, with separate arms of the rock-shaft or the mechanical equivalents thereof; so that from the motion thereof, the valve that keeps its port or ports closed, shall move over a less space while its port or ports is closed, than the one that is opening or closing its port or ports, and vice versa; while at the same time, the two arms by which they are operated have the same range of motion as described; whereby I am enabled to save much of the power heretofore required to work the slide-valves of steam-en-
1278 gines, and by which also I am enabled to give a greater range of motion to the valves at the periods of opening and closing the ports to facilitate the induction and eduction of the steam as specified.

And lastly, I claim the method of regulating the motion of steam-engines by means of the regulator, by combining the said regulator with the catches that liberate the steam-valves, by means of movable cams or stops, substantially as described.

George H. Corliss.

Signed in the presence of
1279 John H. Clark,
E. J. Nightingale.

The counsel for the defendants then put in evidence Letters Patent of the United States, granted to the said George H. Corliss on the 29th of July, 1851, for fourteen years from that day, for a new and useful "improved cut-off gear," together with the schedule and drawings annexed to said Letters Patent, which schedule was as follows:

Schedule

1280 To all to whom it may concern: Be it known, that I, George H. Corliss, of the city and county of Providence, and State of Rhode Island, have invented a new and useful improvement in the method of actuating variable cut-off valves for steam and gas engines; and I do hereby declare that the following is a full, clear and exact description of the same, reference being had to the accompanying drawings which form part of this specification, and in which
1281 figure 1 represents a side elevation of a beam engine, with my valve gear applied thereto; figures 2 and 3 are fragmentary side elevations of the steam cylinder and valve gear; and figure 4 is a section of one of the valve chests and the parts adjacent thereto.

My improvement has reference to that class of cut-off valve motions in which the connection between the valve

and the eccentric or the equivalent thereof, which opens 1282
the valve, is broken to allow the valve to move independently of the eccentric, and close its steam port before the piston has completed its stroke: and my improvement consists in effecting this disconnection of the valve and the eccentric gear or the equivalent thereof, by imparting to the lifting rod a lateral movement which is limited and controlled by an adjustable stop and spring: so that the lifting rod not only performs the duty usually imposed upon it, of opening the valve, but also performs the office of a
catch or latch in connecting and disconnecting the valve 1283
with the eccentric gear.

In the accompanying drawing A is the steam cylinder, and B the crank shaft of the engine. The steam cylinder is fitted with two side pipes C D, which form the valve chests in which the valves are contained. That side pipe C, further from the crank shaft B, contains the steam valves, and is connected with the steam pipe which conveys the steam from the boiler; the other side pipe contains the exhaust valve, and is connected with the exhaust pipe through which the exhaust steam from the cylinder is
discharged. The steam and exhaust valves are in this in- 1284
stance of the slide variety, and each is moved to open and close its respective port, by an arm Y which projects from a short rock shaft Z. These rock shafts extend transversely through stuffing boxes in the sides of their respective valve chests, and their projecting extremities are fitted with arms d d, b b. The arms d d of the exhaust valves are connected by means of lifting rods b b with separate crank wrists c c secured to a disc plate E, to which a rocking motion is imparted by the eccentric F through the intervention of the
eccentric rod d and a crank f secured to the disc plate E. 1285
The connection of these exhaust valves with the crank wrists of the disc plate, and thence with the eccentric are permanent, and hence the exhaust valves will be alternately opened and closed with a regular movement, the opening of one exhaust valve being simultaneous with the closing of the other. The arms g g of the steam-valve rock shafts terminate in toes o o: and are operated by lifting rods h h which are pivoted to suitable crank wrists e e
upon the disc plate E. These lifting rods terminate in 1286
hooks i i which engage with the toes o o of the rock shaft arms, and are kept engaged with them by springs j j which bear upon the backs of the lifting rods; hence as long as these hooks continue engaged with the toes of the rock shaft arms the steam valves will be opened and closed with a regular movement in the same manner as the exhaust valves; while if the hooks of the lifting rods be disengaged from the toes at any portion of the stroke, the connection

Corliss Patent 185

1287 of the steam valves with the eccentric will be broken, and the steam valves will be free to close, and thus cut off the passage of steam to the steam cylinder.

In order to effect this disengagement of the lifting rods which communicate the movement of the eccentric to the steam valves, each rod is fitted with an adjustable stop *k k*, against which the face of the rod bears in moving, and which can be moved to cause the hooked extremity of the rod to detach itself from the respective toe of the rock shaft arm when the steam piston has accomplished any required
1288 portion of its stroke. These stops are constructed to slide in blocks *m m*, secured to the frame work or other convenient portion of the engine; their extremities bear against two inclined blocks *b b*, which are secured to a rod *a*, by raising or lowering of which the stops are moved to effect the disengagement of the lifting rods, when the piston has accomplished a less or greater portion of its stroke. This sliding rod *G*, in the examples represented in the drawing, is constructed to be moved by hand through the intervention
1289 of a rack *n*, and worm *p*; the last of which is turned by hand to screw up or screw down the sliding rod; but the sliding rod *G* may be moved by the engine itself, by connecting it with the slide of the governor, so that as the latter is moved the point at which the cut-off is effected will be varied.

The inclined blocks *l l* are of such form that when they are raised to their highest position, as at figure 3, the stops *k k* will be so far projected that the lifting rods *h h* bearing
1290 upon them, will in moving disengage from the toes of the rock shaft arms before the valves have moved sufficiently to open their respective ports; while if the inclined blocks are depressed by the rod *G* to their lowest positions, as at figure 1, the stops *k k* will recede in their slide blocks *m m*, sufficiently to have no action upon their respective lifting rods, and hence the latter will continue engaged with their respective toes throughout the whole extent of the stroke. If the inclined blocks be set between these two extreme positions, as at figure 2, the stops will be more or less projected, to detach the lifting rods sooner or later, as may be
1291 required to regulate the amount of steam admitted to the steam cylinder.

In order to effect the closing of the steam valves after they are disconnected from the eccentric gear, the rock shaft arm appertaining to each of them has a weight *r* suspended from it by a rod *s*. These weights are sufficiently heavy to effect the instantaneous closing of the valve whenever its appropriate lifting rod is disengaged from the toe of the rock shaft arm.

In order to prevent the slam and jar that would result

from the sudden closing of the valves, these weights are 1292
fitted to move easily in appropriate sockets formed, in the present example, in the bed plate of the engine. The weights moving in the socket, act as pistons to compress the air therein and thus retard their descent, and as air cushions to prevent the slam or jar. If the compression of the air was continued throughout the whole descent of the weight, its motion would be too much retarded to enable it to close the valve with the requisite speed; an orific *t*, figure 1 is therefore made in each socket near its lower extremity, to
permit the free entrance and exit of air. This orifice is in 1293
such a position that the weight in descending passes it and thus cuts off the escape of the air remaining in the socket just before the valve closes its port, when the air, caught or shut up in the socket, being compressed, will retard the further movement of the weight, and will act as an air cushion to prevent the jar.

When the stops are acting, the lifting rods are alternately disengaged in their inward movement towards the centre of the disc plate, to allow the valves to close under the action of their respective weights; as each lifting rod is moved
outward, its extremity being pressed by its appropriate 1294
spring *j* against the toe of its respective rock shaft arm, is caused to re-engage therewith in time to open the steam valve at the returning rock of the disc plate. In order to ensure the closing of each steam valve before it is re-opened, a curved snug *V* is projected from the face of each lifting rod *h*, which in the outward movement of the latter would strike against the lower side of the toe of the rock shaft arm, and thus close the latter, if by any accident it was not previously closed by its appropriate weight.

In order to lessen the wear of the toes and the hooks of 1295
the valve gear, their rubbing faces are faced with hardened plates of steel, which, when worn, can be readily replaced.

The arrangement of the lifting rods, and the method of operating them by the disc plate, as represented in the accompanying drawings, is peculiarly suited to this method of effecting the disengagement of the valves from the mechanism by which they are opened, for the disc plate imparts a transverse motion to the connecting rods which causes them
to rock upon the stops, and thus slide off their respective 1296
toes on the rock shaft arms. But while I prefer this arrangement of eccentric gear, I wish it to be understood that I do not restrict myself to its employment, as my improvement may be applied to many other systems of mechanism by which valves are opened; as such systems may not possess the peculiar rocking motion I have mentioned, it will be necessary, in some cases, to disengage the lifting rods by a positive movement which may at the proper moment be

Corliss Patent 1851

1297 imparted to the lifting rods by some moving member of the engine through the intervention of any convenient and suitable mechanical device.

In combination with the reciprocating motions communicated to the lifting rods by the eccentric gear, I claim imparting a lateral movement to the free extremities of said lifting rods, to disconnect them from the valves, and permit the latter to close to cut off the steam or other expansive fluid by which the engine may be driven, whereby these
1298 rods are made to perform their usual duty of opening the valves, and in addition that of catches or latches in alternately connecting the valves with and disconnecting them from the mechanism by which they are opened, thus greatly simplifying the construction of the valve gear, rendering the same more durable and less liable to get out of order.

In testimony whereof, I have hereunto subscribed my name.

George H. Corliss.

Witnesses—
Thomas A. Jenckes,
1299 Wm. H. Henderson.

It was here admitted by the counsel for the plaintiffs, that the apparatus used by the defendants in their engine, for alternately connecting the steam-valves with and disconnecting them from the mechanism by which they were opened, was constructed and operated like that described in the said schedule annexed to the said letters patent granted to said Corliss on the 29th of July, 1851.

The counsel for the defendants then put in evidence
1300 a duly certified copy from the United States Patent Office of the record of letters patent of the United States granted to Frederick E. Sickels on the 19th of September 1845, for 14 years from that day, and of the schedule and drawings annexed to said letters patent, which schedule was as follows:

The Schedule referred to in these letters patent and making part of the same.

To all to whom these presents shall come:

1301 Be it known, that I, Frederick Elsworth Sickels, of the City, County and State of New York, have invented a new and useful method of tripping the drop-cut-off valves of steam-engines, and regulating and adjusting the same; and that the following is a full, clear and exact description of the principle or character thereof, which distinguishes it from all other things before known, and of the manner of

making, constructing and using the same; reference being 1302
had to the accompanying perspective drawing, which makes
part of this specification.

By the method now practised of operating the drop-cut-
off valve, the motion is derived from the lifter which ap-
proaches its state of rest as the piston of the engine ap-
proaches the middle of its stroke, or its maximum velocity,
and the valve is tripped by the same motion which lifts it;
so that there must be very great nicety in the adjustment to
regulate the extent of the cut-off at about the half stroke.
The object of my invention is to remedy this, and its princi- 1303
ple or character consists in tripping the valve by a motion
independent of the motion of the lifting rod or rods; and
also in combining the various parts in such manner as to
regulate the cut-off with accuracy during the action of the
engine, by connecting the two shafts that trip the two cut-
off valves, end to end, by means of adjustable spring arms
that take into and are when set held in the teeth of a sector,
which vibrates on the axis of motion of the shafts and re-
ceives its vibratory motion from the eccentric; which 1304
spring arms may be shifted in the teeth of the sector,
brought nearer to or farther from each other, and thus cut
off at a less or greater portion of the stroke.

In the accompanying drawing, [A] represents my im-
proved drop-cut-off, secured to me by letters patent on the
day of , 1842, with the lifter [A'] projecting
from the lifting-rod [A''] and operated by the toes of the
rock-shaft [C] in manner not necessary to describe; but in-
stead of disengaging the spring of the lifter [A'] from the
stem of the drop valve, by causing it to strike a permanent 1305
cam as it rises, I employ a long spring [Z'] projecting from
the lifter and fitting in a notch in the stem of the drop valve
as heretofore made, but extending beyond this, and having
a curved projection [S'] on one of its faces, and at the ex-
treme end, against which the outer face of an arm or wiper
[Z] strikes as it vibrates on its vertical axis.

The outer face of this arm or wiper is parallel with its
shaft or axle, and of greater length than the motion of the
lifter so that it can act on the curved projection of the
spring [Z'] as it is carried up and down by the lifter, and
thus cause it to drop the valve. The vibratory motion of 1306
the arm or wiper [Z] is obtained from the eccentric in the
following manner: On its axle there is an arm [W'] con-
nected by a rod [Y] with a similar arm [W] on the upper
end of a vertical shaft [Q] which has a spring arm [T] at
its lower end, (with the outer end handle-form) and its un-
der face provided with a fillet or catch to fall into teeth on
the upper face of a sector [P] that vibrates on the axis of
the shaft [Q] it being attached by means of arms [U, U,]

Sickels patent 1845

1307 that project from two collars that turn, one on the lower end of the shaft [Q] and the other on the upper end of a corresponding shaft [O] below it. From one end of this sector a connecting rod [R] extends to one arm of a bell crank [L], the other arm of which is connected by a connecting rod [N] with the strap [M] of the eccentric [I], and at right angles to the eccentric rod [J] that operates the rocking-shaft [C] of the lifters, so that the sector [P], and the parts deriving motion from it, are at their maximum velocity whilst the rod [J] is passing the dead points of the
1308 eccentric [I] and therefore the motions of the arm or wiper [Z] correspond with the motions of the piston of the engine instead of the lifters; and, therefore, the liberation of the drop valve will be more rapid, and can be regulated with more accuracy than when the motion is derived from the lifting-rods that move slower, as the piston moves faster, and *vice versa.* The shaft [O] which is below and corresponds with the one [Q] has a spring arm [S] similar to and corresponding with the one [T] before described, and at its lower end an arm [B'] and connecting rod [C'] correspond-
1309 ing with the arm [W] and rod [Y] above, and all other corresponding parts to work the lower drop-cut-off valve [B] which is not distinctly represented in the drawings, and which needs not to be shown, as all these parts correspond in every particular with those above described. The sector [P] has a plate [P'] above and parallel with it, for the purpose of strength and to act as a guard for the spring arms [S, T,]. The face of the sector [P] is provided with two sets of teeth, each extending from the middle or arms [U, U] to the ends, and the length of each
1310 section should be such that the motion of the spring arms [S, T] from one extremity to the other shall shift the position of the wiper or arm [Z], so that when the arm is at the outer end of the segment of teeth, the arm or wiper shall vibrate without dropping the valve, and thus act without the cut-off, and by moving it towards the middle the extent of the cut-off shall be decreased from the maximum to the minimum, that is to say, cut off from the most to the least portion of the stroke.

1311 It will be evident from the foregoing, that any motion derived from any part of the engine may be substituted for the vibration of the arms or wipers, provided the character above described be maintained, as for instance, instead of the horizontal vibrating motion of the arm or wiper, the spring may be disengaged from the stem of the valve by a vertical descending motion as the lifter rises, and this may be derived from any moving part of the engine other than the lifters or their rocking shaft, such as the piston-rod, the beam, the crank, shaft, &c.

What I claim as my invention and desire to secure by 1312
letters patent, is tripping the drop-valve of the cut-off by a motion independent of the lifters, substantially in the manner and for the purpose herein described.

I also claim combining the wiper that drops the valve of the cut-off, whether working horizontally or vertically, with any of the moving parts of the engine, other than the lifters or their rocking-shaft, by means of the sector and arm or arms, by means of which the extent of the cut-off can be regulated at pleasure during the action of the engine, from
the full to the least portion of the stroke, as herein de- 1313
scribed.

Frederick Elsworth Sickels.

Chas. M. Keller, }
A. P. Browne, } Witnesses.

The counsel for the defendants' then put in evidence a duly certified copy from the United States Patent Office, of the record of letters patent of the United States, granted to Frederick E. Sickels on the 24th of February, 1852, for 14 years from that day, and of the schedule and drawings annexed to said letters patent, which schedule was as
follows: 1314

The schedule referred to in these letters patent, and making part of the same.

To all whom it may concern, be it known that I, Frederick E. Sickels, of the city, county and State of New York, have invented a new and improved mode of tripping cut-off valves, and I do hereby declare that the following is a full and exact description thereof, reference being had to the accompanying drawings, and to letters of reference marked
thereon. 1315

In cut-offs as heretofore constructed, in operating the catch by the closing movement alone, the valve could not be tripped until sufficient motion had taken place to operate the whole extent of the catch, thus occasioning an unavoidable delay in tripping the valve.

The nature of my invention, therefore, consists in operating the catch or hold, and liberating the valves of trip cut-offs, on the movement to close or return of the valve, by
means of an adjustable cam or lever, after it has been 1316
partially operated upon on the opening movement of the valve motion, so as to leave as little movement of the catch to effect the liberation of the valve as may be desired, to be accomplished by the return movement, thereby being enabled to liberate the valve, and cut-off the steam as near the first of the return movement as may be desired.

Fig. 1, side-view. Fig. 2, front-view. *A*, toe on the rock-

1317 shaft. *B*, foot on the lifting-rod. *C*, lifter. *D*, valve-stem. *E*, catch-piece on lifter, having a projection catching under the socket *F*, at *G*, *H*. *J* and *K*, are two arms, having wedges or inclined planes, *L*, *M*, upon them as shown in figs. 3 and 4, they being edge-views, and the same letters referring to the same parts on each. Fig. *N*, lever upon which the arms *J* and *K* connect with joints at *O* and *P*, the lever itself vibrating upon a pin at *Q*, and being connected with an adjusting rod *S*, by a joint and pin at *R*. *U*, an adjusting screw-socket, working on the adjusting rod
1318 *S E*. Fig. 5 top-view of catch-piece or lever, having a projection catching under the socket *F*, at *G*, *H*. *V*, wedge-piece on *K*, having its inclined plane or wedge-surface running in the direction from 1 to 2. The other wedge-pieces, on the arms *J* and *K*, having their wedge or inclined surfaces running as shown in edge-views of the arms, Figs. 3 and 4, in the directions from 4 to 5, and from 6 to 7, one wedge having its larger part downwards, as shown in Fig. 4, and the other the larger part upwards as shown in Fig. 3. W, Figs. 3 and 4, section of lifter, holding the lower end of the arms *J* and *K* from being moved out of their proper
1319 position when the wedges *L* and *M* act upon the catch-piece. *X*, *X*, Figs. 3 and 4, section of catch-piece at the part where it is acted upon by the wedges *L* and *M*, its extreme end at that part being beveled in the direction from 8 to 9, Fig. 1.

The operation is as follows: The wedges or inclined planes *L*, *M*, *V*, being in the position shown in the drawings, (figs. 1 and 2,) and the catch-piece *E*, moving upward, in the opening movement, from the dotted line *Y* to the dotted line *Z*, as represented in the drawing, in figs. 1, 2, 3 and 4, then, as the catch-piece moves upwards, its inclined
1320 end at 8, 9, strikes the face of the wedge or inclined plane, *V*, at 1, 2, and moves it in the direction of from 10 to 11, the arm *K* turning on a joint at *P*, the wedge *L* moving out the catch-piece until it has reached the extent of its upward movement, and is about to return, the projection on the catch-piece being then under the socket, as shown in fig. 5, and the end of the catch-piece being in the position shown by red lines 12, 13, figs. 3 and 4. The wedge *M* now moves back under the end of the catch-piece, the arm *K* turning on the pin at *P*, and being actuated by a ball or
1321 weight, and on a horizontal extension of the arm *K*, now by the first of the return movement the catch-piece passes over the larger part of the wedge *M*, and is thereby entirely moved out from under the socket, and the valve attached to the valve-stem is permitted to close.

By turning the adjusting screw-socket *U*, so as to lower the wedge *L*, and raise the wedge *M*, the catch-piece would

be further moved out from under the socket by the opening motion, and leave less to be accomplished by the return motion, thereby cutting off the steam nearer the first of the return movement, and by turning the adjustable socket so as to raise the wedge *L*, and lower the wedge *M*, the upper movement would operate the catch-piece less, and the downward movement more, thereby cutting the steam off farther from the first of the return movement. Fig. 6 represents in perspective a portion of the two arms *J*, *K*, with their wedges or inclined planes, *L*, *M*, *V*, and the catch-piece *E* detached from the other parts of the apparatus. 1322 1323

Having thus fully described my invention, what I claim therein as new, and desire to secure by Letters Patent, is operating the catch or hold, and liberating the valves of cut-offs, on the movement to close or return motion of the valve, after it has been partially operated upon in opening, substantially in the manner as herein described, so as to leave as little of the catch to be operated, to effect the liberation of the valve, as may be desired to be accomplished on the return movement, thus being enabled to liberate the valve, and cut off the steam as near the first of the return movement as may be desired. 1324

FREDERICK E. SICKELS.

A. B. STOUGHTON, } Witnesses.
JAS. S. EWBANK, }

(The counsel for the plaintiffs in due time objected to the introduction in evidence of both or either of the said Letters Patent granted to said Sickels severally in 1845 and 1852, but the objection was overruled by the Court.)

The counsel for the defendants then put in evidence a duly certified copy from the United States Patent Office of a caveat filed therein by Frederick E. Sickels on the 14th of January, 1842, and of the file belonging to said caveat, and of a letter from said Sickels to the Commissioner of Patents, dated April 19th, 1844, of which caveat, file and letter the following are copies: 1325

TO THE COMMISSIONER OF PATENTS:

The petition of Frederick Ellsworth Sickels, of the City, County and State of New York, respectfully represents—

That he has made certain improvements in the mode of cutting off steam in the operation of steam-engines, and is now engaged in making a model to show the principles of the invention, preparatory to his applying for Letters Patent therefor.

He therefore prays that the subjoined description of his

1326 invention may be filed as a caveat in the confidential
acrhives of the Patent office agreeably to the provisions of
the act of Congress in that case made and provided, he hav-
ing paid twenty dollars into the Treasury of the United
States, and otherwise complied wifh the requirements of
said act.

New York, Jan. 11, 1842.

Fig. 1, (1st drawing) is a view of the contrivance for trip-
ping the valve-stem *B* loose from the lifter *C*. The spring
A keeps under the feathers *D D*, fastened to the valve-
1327 stem *B*, while the lifter is rising, thereby compelling
the valve to rise also. As the end of the spring at *E* passes
the face of the wedge *F* it is crowded in as the face of the
wedge from from *G* to *H* slopes in, that is towards the
screw *I*. After the edge of the spring *A* at *E* has arisen
above the edge of the wedge *F* at *H*, it regains its former
position; its edge at *E* is a little outside of the wedge at *H*.
Now as the lifter descends, the edge of spring at *E* travers-
es the inclined plane from *H* to *I* of the wedge *F*; the spring
is by this means forced from under the feather *D*, thereby
1328 allowing the valve to drop. There is another wedge like
F on the other side to force out the other arm *X* of the
spring *A* from under the other feather D^2. If it is required
that the piston shall complete a greater portion of the stroke
before the cut-off acts, the piece *K* having two wedges at-
tached is moved down on the plate *L*, which plate *L* is fast-
ened to the bonnet *M*. If the piston is to perform a less
portion of the stroke when the cut-off acts, the piece *K* is
turned over so that the edge *G* of the wedge *F* is upon
the other side; it is again put on the plate *L* and moved
1329 lower down, where it is held by the clamp-screw *I*, which
screw passes through the slot *N*, and has a collar and
thumb piece on the other side. 1st drawing, fig. 2, is a
view of the contrivance for preventing the valve from slam-
ming, as it would appear if cut through the middle longi-
tudinally and one half only seen. *A* is a reservoir two
thirds full of water, bolted fast to the steam-chest under the
steam-valve. *B* is a continuation of the valve-stem *B* in
Fig. 1, passing through the steam-chest and attached to a
1330 plunger, *C*. *D* is a reservoir placed inside of the reservoir
A, and is susceptible of being moved up or down by means
of the stem *D*, which passes through a stuffing-box at *E*,
screws through the stuffing-nut at *F*, and also through the
jam-nut *G*. By turning the stem *E* with a wrench on at *H*,
the stem *E* rises, and with it also the reservoir *D*. As the
stem *E* descends through the water, it suffers more resist-
ance the nearer it approaches the bolts of the reservoir *D*,
in consequence of the bottom of the reservoir being more
contracted than the top, and consequently leaving less room

for the water to escape. By raising the reservoir *D* the 1331
resistance to the plunger *C* is increased, which provision is
necessary to suit the height from which the valve is trip-
ped; if it is found necessary, a globe-cock may be used to
keep up a proper supply of water, and also a cock may be
used to let off the surplus water that may be formed by the
condensation of the steam. Drawing No. 2, Fig. 1, plan for
a cut-off arranged for the top valve of single valve engines.

There is about four inches cut out of the lifting-rod to
which the top steam-lifter is attached at about one foot from
the lower bearer on the top steam-chest as represented by 1332
the dotted lines at *P*; the foot *Q* is keyed on the upper por-
tion of the lifting-rod and extends down over the lower
portion when the valves are all down; the feathers *D D*
are fastened to the lower portion of the lifting-rod and come
in contact with the under side of the spring A; the top side
passes under the foot *P*, but as here shewn, has been forced
out from under by wedges in the manner before described
in drawing No. 1, sufficiently to allow the foot and upper por-
tion of the lifting-rod to descend with the upper steam-
valve and by this means cutting off the steam. When the 1333
lower portion of the lifting rod commences to raise, the up-
per portion is raised by it, the springs then being under the
foot so as to come in contact with the feathers *D D*, and are
only forced out in the position represented when the cut-off
acts. The rod *R* keyed to the foot *Q* at *S*, is fastened to
another rod *V*, by means of an adjusting socket at *T*, which
rod passes through a stuffing-box at *W* into a reservoir *X*,
and is connected to a plunger, *Y*, represented by dotted
lines. The adjusting socket-joint at *T* serves to raise and
lower the plunger *Y*, thereby altering the resistance as be- 1334
fore described in drawing No. 1.

Drawing 2, Fig 2, *C* is a lifter keyed to a tube *O*, which
extends to the middle bearer attached to the side pipes
above, and four inches below the first bearer under the
steam-lifter. The lifter with the tube attached is disconected
from the lifting-rod as the spring *A* is forced out from under
the two feathers *D D*, represented by dotted lines, which
feathers are fastened to the lifting-rod *Q*; the springs are
forced out from under the feathers as before described in
drawing No. 1. 1335

W and *R* are rods which serve to connect to a dasher in
the reservoir *X*, there being a stuffing-box on the under
side of the reservoir where the rod passes through.

1st. What I claim is using a reservoir of water and a
plunger to prevent the valve from slamming.

2d. The tripping of the valve-stem loose from the lifter
at any portion of the stroke of the piston.

3d. The tripping of the lifter loose from the rod.

1336 4th. Tripping one portion of the lifting-rod loose from the other.

Caveat.
Fredk. E. Sickels,
New York.

Cut-off valve for steam-engines.

Fredk. E. Sickels,
Town of New York,
County of do.,
State of do.

Cut-off valve of steam-engines.
Rec'd Jany. 14, 1842.
Cash, $20 pd.

Another drawing, which was on file, arranged for double
1337 valve, was delivered to Mr. Cook May 23, 1844.

A. L. McI.

Drawing of the single valves deliv'd to Mr. Cook on letter shown me by Mr. C.

A. L. McIntire.

New York, April 19th, 1844.

Hon. Henry L. Ellsworth:

Dr. Sir,—Will you please permit Mr. Truman Cook, the bearer hereof, to have the drawing of my patent cut-off which was deposited with a caveat, I think, in the month of March, 1842, and much oblige

Yr. obt. servt,
1338 Frederick E. Sickels.

The counsel for the defendants then offered to show that an apparatus substantially identical with that described in the said letters patent granted to Frederick E. Sickels on the 20th of May, 1842, and covered by the first specification of claim in said letters patent, and an apparatus substantially identical with that described in the said last named letters patent and covered by the second specification of claim therein, had been successfully used on board the steamboat South America running from New York to Al-
1339 bany in April, 1841.

The counsel for the plaintiffs objected to the introduction of the evidence so offered.

The Court decided that the evidence was admissible so far as it might be brought to bear upon the question of identity or non-identity between the two several apparatus of the plaintiffs and the two several apparatus of the de-

fendants, but that it could not be introduced to affect the 1340
validity of the patent to Sickels.

The plaintiffs' counsel excepted to the decision of the Court.

The counsel for the defendants then read in evidence the deposition of *Robert Robinson*, taken on direct examination before Joseph S. Pitman, United States Commissioner, at Providence, Rhode Island, May 11th, 1853, and on cross-examination before Joseph Bridgham, United States Commissioner, at New York, May 12th, 1853, which deposition,
without the drawings referred to therein and annexed there- 1341
to, was as follows :

I, *Robert Robinson*, of the City, County and State of New York, being duly sworn according to law, on oath depose and say :

1*st Question by T. A. Jenckes, Esq., for the Defendants.*

Balloon

1. What is your residence and occupation ?

A. My residence is in New York; my occupation is an
engineer; I am now chief engineer of the United States 1342
mail steamship *Baltic.*

2. Where were you employed in years 1840 and 1841; and in what capacity?

A. I was employed in the Phenix Foundry, in New York, owned then by James Cunningham, in the capacity of an apprentice at steam-engine building; I was an apprentice there from 1835 to 1842.

3. While you were employed there, did you know of the construction of a tripping apparatus for a drop cut-off for
the steamboat *Balloon*, and if so, when was it made, and 1343
was it placed upon said boat; and if not, why not?

A. I did know of the construction of such apparatus; I am not positive when it was made; it was either in the year 1839 or 1840; it was not placed on said boat, on account of there not being sufficient time, as the boat was chartered by Capt. Woolsey, and taken from the North River, before the work for the cut-off was completed.

4. Do you know of the construction of a drop cut-off for the steamer South America, at Cunningham's Foundry?

A. I do know that there was a drop cut-off made at the 1344
Phenix Foundry, and put on the steamboat *South America.*

5. Did you work upon that engine and that cut-off?

A. I did work while the engine was being fitted in the boat.

6. When was the tripping apparatus for that cut-off commenced?

1345 A. I think in the spring of 1840.

7. When was the engine completed and placed in the boat?

A. In 1841, in the month of April, the engine was finished.

8. Will you describe the tripping apparatus as it was constructed and placed on that boat?

A. The valve was raised in the ordinary way by a lifting rod and a lifter, and was tripped by a cam or inclined plane connecting with a slide, operating on the valve stem. The
1346 slide was constructed in the shape of a fork which was drawn out of slots on the valve stem; that is the way the valve was tripped.

9. What contrivance was first used for checking the descent of the valve?

A. A spiral spring was used on the lower end of the valve stem.

10. Did this answer the purpose?

A. It did not—on account of the falling of the valve breaking the spring.

11. What was used next, and with what result?

1347 A. Leather washers were next used, and did not answer the purpose.

12. What was then tried, and in what manner, and with what success?

A. A cylinder was then tried with air; there was a piston in the cylinder secured to the valve stem, with an internal and external valve on the bottom of the cylinder; also a cock fastened to the cylinder between one and two inches from the bottom; that did not answer the purpose.

13. What was the difficulty in this last arrangement?

1348 A. It could not be adjusted so as to prevent the valve from falling heavily.

14. How many trials were made of this air cylinder?

A. I should think there were two trials made with steam on the engine.

15. What was next used and in what manner?

A. Water was next used in the cylinder, with a conical plunger; that did not succeed, as the water was not confined in the bottom of the cylinder.

1349 16. Were any alterations made in the cylinder for the use of water, and if so, what were they, and how did they operate?

A. The cones or conical plungers were taken out and made parallel, which perfected the dropping of the valve, by using water.

17. Were any alterations made in the bottom of the cylinder, and if so, what?

A. The bottoms of the cylinders were taken off, and cups

inserted in the bottom to fit the parallel plunger; the cups 1350
were arranged so that they could be adjusted at any time with a screw through the cylinder bottom and so regulate the cups and prevent the valve from falling heavily.

18. Were these changes made before or after the boat commenced her regular trips?

A. They were all made before the boat commenced her regular trips.

19. By whom were the drawings and plans of this cut-off made?

A. They were made by Mr. Hogg. 1351

20. Who was employed in constructing and setting up this cut-off?

A. I was employed in constructing and setting up the cut-off under the direction of Mr. Hogg. Others were employed with me—one of them was named George Birkbeck.

21. When the boat started upon her regular trips were any persons sent from Cunningham's shop to watch the working of the engine, and, if so what persons?

A. Myself and George Birkbeck were so sent.

22. How did the cut-off work on those trips? 1352

A. It appeared to work well as we had no alterations to make on the cut-off and had no orders to do so.

23. Where was the cylinder placed?

A. Directly below the steam-valve, fastened to the steam-chest?

24. Did steam escape at any time into the cylinder?

A. I never saw any leakage from the valve stems. One could not see inside of the cylinder.

25. Do you remember of water being applied to the cylinder for any purpose? 1353

A. I remember water being applied to the outside of the cylinder, to condense the steam said to be in the cylinder. I was told that it was there. I couldn't see it. I was told so by Mr. Hawes, then engineer of the People's line of steamboats in which line the *South America* was running.

26. On what trip was this?

A. On the trial trip to Piermont, in April 1841.

27. How many regular trips of the boat were you upon after her first starting?

A. I should think I was on four regular trips. I mean by 1354
a trip, from New York to Albany and returning.

28. On what trip did the *South America* break down?

A. She broke down on her fifth trip, the one after I left her.

29. On what day did she break down, and how do you fix the date?

A. She broke down on Saturday, I think, the 24th of

1355 April, 1841. I fix the date by seeing it advertised; I don't recollect now in what paper. I saw the advertisment the 2d or 3d of May, 1853.

30. Was this cut-off injured at the time of breaking down?

A. Not to my recollection.

31. Were you employed in repairing the engine after the break down?

A. I was employed in repairing the bed-plate and condenser.

1356 32. Did you go to Albany in her for the purpose of watching the operation of the engine after it was repaired?

A. I have no recollection of doing so.

33. How long did this cut-off remain in use on the South America?

A. It remained to the best of my knowledge about five years?

34. Was any alteration made in it to your knowledge?

A. Not to my knowledge.

35. Will you now make drawings from your recollection of the cylinder as used with air and water for the purpose
1357 of checking the descent of the valves on the *South America* and describe what those drawings represent?

A. I will do so. (The drawings hereto annexed marked A, were here prepared by the witness.) Fig. 1, represents the air-cylinder, with piston, valves, and cock, lever, &c. Fig. 2, represents the water cylinder, conic plunger, adjustable cup, &c., as used first after the air cylinder. Fig. 3, represents the cylinder as finally used. The difficulty with No. 2. was that the water was not confined in the bottom of
1358 the cylinder. We then bored out the lower cup in the cylinder so that its sides were parallel; we reversed the plunger on the valve-stem and made it to fit the lower cup in the cylinder, by a piece of boiler-plate on the lower side of the plunger.

36. Was there any difficulty in its working after this last change?

A. There was not any difficulty. It was considered finished perfect.

37. What person made these last alterations and under
1359 whose direction?

A. Mr. Hogg ordered the alterations made. Myself and others did the work. I recollect putting that boiler-plate on and assisting in all the alterations.

38. Were or were not all these alterations made before the *South America* broke down?

A. They were all made before.

39. Were they so made before she started on her first regular trip in the People's line?

A. Yes, they were all made previous to her taking her place at the wharf in the People's line. 1360

ROBERT ROBINSON.

Taken *de bene esse* at the request of the defendants in the cases of Wm. B. Sickels, et al. *vs.* Youngs and Cutter, and same *vs.* The Gloucester Manufacturing Company, now pending in the U. S. C. Court for the Southern District of New York, and sworn to and subscribed before me this eleventh day of May, A. D., 1853, at Providence in the District of Rhode Island.

JOSEPH S. PITMAN,
U. S. Commissioner for the R. I. District. 1361

(*The witness being cross-examined by Mr. Dickerson on the part of the Complainants.*)

1. Do you use Sickels' cut-off on board of the *Baltic?*

A. We do.

2. Do you not think it a very valuable improvement?

A. I do, over the old cut-off.

3. About how much fuel will it save over the old cut-off? 1362

A. I cannot say, as I have never used the old cut-off.

4. Was the cut-off apparatus which was constructed for the *Balloon* in 1840, put on to her at any time?

A. It was not, on account of not having sufficient time. The boat was chartered and sent away from the North River before the cut-off was finished.

5. Was it not put on her afterwards?

A. I cannot say.

6. How long was it after you first had steam on the *South America*, before you started on your trips to Albany, April 24th, 1841? 1363

A. We had steam on the engine three or four different times; I cannot say how long after we had steam on that we started.

7. Did you have steam on her as many as five times?

A. I should think we had, I cannot say positively.

8. Did you make any trial trips before the 24th April, and if so how many?

A. We made three or four trial trips previous to 24th April.

9. How made times did you have steam up besides those trial trips.

A. Two, probably, or three; can't say positively.

10. Was the engine hooked on and worked at the dock on those occasions?

A. It was to try the cut-off.

1364 11. Where was the spiral spring placed on the valve-stem?

A. The spring to prevent the valve from falling heavily, was placed on the lower end of the valve-stem; the spring was enclosed in a socket which was outside of the valve-chest.

12. Was the steam around the spring, and in contact with it?

A. It might have been, as there was a stuffing box at the lower end of the valve stem—can't tell if the stuffing box leaked or not.

1365 13. How many times did you try with this spring?

A. Once or twice.

14. Did you try twice?

A. I should say we did.

15. Did you try the spring on the trial trips, or any of them?

A. Not that I recollect.

16. How many times did you try leather?

A. Once, I think, and then took it off.

17. Was that on a trip?

A. I cannot say positively. I think it was along side the
1366 wharf.

18. Did you put on the air cylinder as soon as you took the leather off?

A. I think that was the next experiment tried.

19. How long after the leather experiment was it, when you tried the air?

A. I cannot say the exact time, as soon as the cylinder and the piston for the cut-off could be made.

20. How many times did you try air?

A. I recollect making one trial trip with air, and once
1367 previous to that.

21. What was the weighted valve in the bottom of the air cylinder used for?

A. To allow the air to escape from under the piston.

22. Did that valve open as the piston descended?

A. It did open as the piston descended.

23. What was the stop cock for in "figure 1," annexed to direct examination?

A. It was put in to answer the purpose of a lower escape
1368 valve, before putting in the escape valve.

24. How many times did you try with the stop cock?

A. Not more than once or twice, I can't say positively.

25. Why did not that work?

A. It allowed the valve to fall heavily on its seat making a great noise.

26. Would it do so if it were shut nearly close?

A. At times it would; as the steam varied, the cock would require to be closed and opened.

27. Did it work well with some pressures? 1369

A. The owners were not satisfied with the valves at any time, with air.

28. Did it work better with the weighted valve?

A. Not that I recollect.

29. Was there any difference in their mode of operation?

A. There was not.

30. Did you see Mr. Hogg make the drawings of this cut-off?

A. I did not. I never saw them till they were sent in the shop.

31. Who made the drawings for "figure 2," annexed to 1370
your direct examination?

A. I think Mr. Hogg.

32. Was there a new cylinder for "figure 2?"

A. No, merely a new bottom.

33. Was that bottom made at the same time that the cylinder was, or afterwards?

A. The bottom was made after they tried the air in the cylinder?

34. Did the bottom of the plunger of "figure 2" correspond with each other in shape so as to fit one another?

A. Yes, nearly so. 1371

35. Did not the plunger then shut up the bottom when it was in it?

A. It did when they were in contact, but did not prevent the slamming of the valve, as it threw the water out of the lower cup.

36. Did not the plunger as it descended gradually close the lower cup, and gradually diminish the escape room for the water?

A. It did; but as the cup was of a conical shape, it did
not arrest the valve in proper time. 1372

37. Are not the cups on the *Baltic* conical shaped?

A. They are not; they have parallel sides.

38. Is not the plunger conical shaped where it enters the cup?

A. No, it is quarter round on the lower end of the water plunger.

39. Is it not smaller where it first enters the cup than it is where it finally stops?

A. Yes, it is a fraction smaller; probably the sixteenth
or eighth of an inch. 1373

40. Does it make any difference in the principle or operation of the dashpot whether the cup is tapering, and the piston cylindrical, or whether the piston is tapering and the cup cylindrical?

A. I never saw it tried, I should think it would make no difference.

41. Was the air-piston fitted tight to the cylinder?

1374 A. It was a loose fit so that it could be moved in the cylinder by hand.

42. How many times was the "No. 2" arrangement tried before you tried "No. 3?"

A. It might have been tried twice, I could not say positively.

43. Was the cylinder in all these operations tight, so that it confined the steam if any leaked into it out of the chest?

A. Yes; all except the one with the valves in the bottom; I cannot say whether the bottom was tight or not.

1375 44. Did you never make a trip to Albany with "No. 2?"

A. I never did.

45. Are you perfectly certain that this bottom was put into the cylinder before you went to Albany?

A. I am; as the valve made a good deal of noise until that bottom was put in.

46. By what circumstance can you recollect that the bottom was put in before you went to Albany?

A. The bottom in "figure 3" is the same bottom as was in "figure 2," the insides being made parallel.

47. Is there no other circumstance but that by which you
1376 fix this date of putting in this bottom?

A. I recollect I was told by Mr. Hogg to take the lower cups out, and have them bored parallel, reverse the plunger on the valve-stem, and put a piece of boiler plate on the lower side of the plunger, and put it together again. I recollect the circumstance as I was told to do this myself.

48. How do you recollect that you was told to do this before the boat went to Albany?

A. Because everything else that was tried allowed the valve to drop heavily on its seat; after the last operation in
1377 figure 3 the valve came down gradually, and all parties concerned seemed to be satisfied with that arrangement.

49. How do you know that figure 2 was made before you went to Albany?

A. I know that I made the first three or four trips in the boat, and she never made a trip to Albany till the drop was arranged to drop easily.

50. When it was arranged, was it not considered a very valuable invention?

A. Yes, it was something new, and was supposed to be
1378 very economical for fuel.

51. Was this the opinion of Hogg & Cunningham?

A. I never heard them express an opinion. I have heard others whom I suppose knew about those matters.

52. Did Mr. Hogg claim to be the inventor at that time?

A. He made the drawings for the cut-off, and it was called Hogg's cut off. I never heard him say he was the inventor.

53. By what name is this cut-off known now? **1379**
A. It is now called Sickels' cut-off.
54. Did you at that time hear any one connected with Cunningham's foundry claim to be the inventor of it?
A. I heard Cunningham and Hogg say they were making something new; I never heard them claim to be the inventors of it.
55. Do you know who is the inventor?
A. I do not; I always supposed it lay between Cunningham, Hogg, Sickels, and others,
56. Was there ever air used in No. 2 or No. 3? 1380
A. It might have been on No. 3 just to experiment with previous to getting on steam; I don't think it was ever used on No. 2.
57. Can air be successfully used in a dash-pot constructed as Sickels usually makes them?
A. I never saw it used successfully on one of Sickels'; I cannot say whether it could be used successfully or not.
58. Who first called your attention recently to the fact that the water dash-pots were used on the *South America* 1381 before she went to Albany?
A. In speaking of dash-pots, I always knew that water had been used in the dash-pots on the *South America*. Mr. Barstow was the gentleman who asked me what I knew about the cut-off.
59. Did you always know that water had been used before you went to Albany?
A. No, I did not. I always knew that water had been used in the *South America* since the alteration of her cups. 1382
60 When did you first know that water had been used before you went to Albany, and by what means did you acquire that knowledge?
A. I knew that water was used in the cut-off about the month of April, 1841: I acquired the knowledge by putting the water in myself, by direction of Mr. Hogg, or some of the proprietors of the establishment.
61. Has Peter Hogg talked to you about the *South America* lately?
A. He has.
62. Did he tell you that this cut-off was completed on 1383 the *South America* before she went to Albany?
A. He did not. I judged myself the cut-off was finished while the boat was running from New York to Albany, as I had no orders to do any work at it.
63. Did he talk about the question whether the cut-off was finished before you started for Albany?
A. No, sir; he merely asked me what my recollection was about the different apparatus to prevent the slamming

1384 of the valve, and I made two or three sketches similar to No's. 1, 2 and 3.

64. Was the cut-off arrangement which was first put on the *South America* like that which was constructed for the *Balloon?*

A. I never saw much of the *Balloon's* cut-off. I never examined it. I saw it lying at the shop; I think some parts were like the *South America's*.

65. Was there any change made in the cut-off of the *South America* after she broke down to your knowledge?

1385 A. I think the cams or inclined planes were connected together, so as to regulate the cutting-off-point from the engine-room; this was after she broke.

66. Was this done by rods of iron or wood work?

A. By a rod of iron and a lever—a wrought-iron rod and lever.

67. Was any other change made that you know of?

A. Not to my knowledge.

Re-Direct.

68. Do you recollect the date in your direct examination

1386 of the breaking down of the *South America?*

A. I saw the date in the paper, 24th April, 1841. That was the date of the breaking down.

69. How many trips did you make to Albany before the breaking down?

A. I think four trips, making eight days.

70. What was the usual time of performing a trip in the People's Line?

A. Forty-eight hours.

71. Did you run on Sundays?

A. No, sir.

Cross-examination resumed.

72. What day did you start on your first trip?

1387 A. April 15th.

73. When you were making trials did you get up steam more than once a day?

A. We got up steam once a day on the boilers, and kept the steam on six or eight hours.

ROBERT ROBINSON.

Examination taken, reduced to writing, and by the witness subscribed and sworn to this 12th day of May, 1853, before me,

JOSEPH BRIDGHAM,
U. S. Commissioner
for the Southern District of New York.

The counsel for the defendants then read in evidence the 1388
deposition of *Robert Robinson*, taken before John W. Nelson, United States Commissioner, at New York, December 7th, 1854, which deposition, without the deposition, models or drawings referred to therein, was as follows:

Q. 1. What is your name, residence, age and occupation?

A. My name is Robert Robinson; my residence, New York; my age, 31; my occupation, an engineer; am chief engineer of United States Mail steamship *Baltic*.

Q. 2. State whether you are about to leave the city of New York to go to sea, or elsewhere; and if so, when and where?

A. I leave New York on Saturday next, the ninth in- 1389
stant, for Liverpool, in the *Baltic*, in my employment as engineer.

Q. 3. Look at the paper herewith shown to you, and hereto annexed, marked A, consisting of ten pages of written matter, and one sheet containing three figures of drawings, and state whether or not it is the original of your deposition in this case, taken on the 11th May, 1853, at Providence, Rhode Island, on the part of the defendants, before Joseph S. Pitman, United States Commissioner?

A. The drawings and deposition are mine, and the paper is the original of such deposition and drawings.

Q. 4. Look at question 35, and the answer thereto, con- 1390
tained in said deposition, and also at the said drawings, and state whether the said drawings are the drawings referred to in the answer to the said 35th question, and whether said drawings were made by you?

A. The drawings were made by me, and they are the ones referred to in the answer.

Q. 5. Look at the models now shown to you, consisting of seven pieces, marked respectively B, C, D, E, F, G and H, and which are severally certified by the Commissioner by certificates, on each of which you have written your name, and state what such models and pieces severally represent?

A. The pieces marked B, C and D, when put together, represent the apparatus shown by figure 1 of the drawings
before referred to, and hereto annexed. The piece marked 1391
E, being a conical plunger, with the valve-stem and nut taken out of the piece marked G and applied to said piece marked E, and also the piece marked F, and also the piece marked B after unscrewing therefrom the bottom thereof with the valve arrangement of said bottom, and also after unscrewing therefrom the cock in the circumference thereof, and closing up the orifice where the said cock is inserted, and applying to the cylinder of said piece marked B the bottom piece taken from the piece marked G, with the screw and nut attached to said bottom piece, which bottom piece

1392 is separately marked I, said last mentioned screw being inserted in the bottom of the piece or cup marked F, and the piece or cup marked F being inserted in the bottom of the cylinder of the piece marked B, when put together, represent the apparatus shown by figure 2 of said drawings, before referred to, and hereto annexed. In said figure 2, the piece marked E is inserted in the piece marked F, so as to fit the conical cup in said piece marked F. The piece marked E, inverted, and with the largest circumference thereof applied to the face of the piece marked
1393 H, and the valve-stem, screw and nut taken from the piece marked C, and applied to said pieces marked E and H, and then the whole inserted, with the piece marked H downwards, in the cylindrical cup of the piece marked G, and then the whole applied to the cylinder of the piece marked B, together with the bottom piece I of the piece G, with the screw and nut belonging thereto, said bottom piece marked I being applied to the bottom of the cylinder of the piece B, instead of the bottom and valve arrangement now attached thereto, the cock in said cylinder being removed
1394 and the orifice thereof closed up, as before described in figure 2, when put together, represent the apparatus shown by figure 3 of said drawings before referred to, and hereto annexed.

Counsel for complainants objects to the testimony as irrelevant to the questions ordered to be tried on the feigned issues in this action.

R. Robinson.

Sworn and subscribed before me,
this 7th December, 1854,

J. W. Nelson,
U. S. Comr.

(The deposition, Exhibit A, is hereinbefore set forth at
1395 pages 273 to 277, folios 1341 to 1361.)

The defendants then called as a witness—

Peter Hogg, who, having been duly sworn, testified as follows:

Q. What is your occupation?

A. I am an engine-builder, in New York.

Q. How long have you been engaged in that business?

A. Since 1837.

Q. Were you, at any period previous to 1842, acquainted with the tripping apparatus used for the purpose of producing a cut-off in steam-engines?

A. I was, sir.

Q. When were you first acquainted with it?

A. I contrived an apparatus myself for that purpose, in the latter part of the year 1838.

Q. Where were you then employed?

A. I was employed at the Phœnix Foundry, New York.

Q. Who was then the owner of that establishment? 1396

A. Mr. James Cunningham.

Q. Will you describe the apparatus you then contrived?

A. It was an apparatus for releasing the steam-valves from the lifter which raised them, and allowing them to fall to their seats, for the purpose of effecting a cut-off.

Q. How was the detachment effected?

A. It was effected by a bolt or slide which was fixed upon the top of the lifter, and withdrawn by a fixed cam.

Q. Have you constructed any cut-offs upon that plan?

A. We have, sir.

Q. When? 1397

A. The first set in operation was on board the steamboat *South America.*

Q. Was that the first one constructed?

A. Not the first one constructed; one had been previously made for the steamboat *Balloon*; in the course of its construction the boat was chartered and sent from the city, and the order was countermanded by the owners, they not having time to have it completed.

Q. Describe the construction of that which was put upon the *South America.* 1398

A. This model is a correct representation of the tripping apparatus that was made and put in use on board the *South America*; this was in the spring of 1841.

Q. Describe the operation of that model.

A. This lifting-rod was a portion of the mechanism for moving the valves of steamboats, in common use, and the lifter was ordinarily attached to the valve-stem by nuts above and below; the upper part of the valve-stem being removed, or a piece substituted for the thread and nuts, in which piece there were catches at the side for admitting the end of a bolt 1399
or latch, which was forced in by means of a small spiral spring upon it, that, by the ascent of the lifter, being drawn back from the notches in the valve-stem, by means of a cam or wedge-piece, released the valve from the lifter and allowed it to drop to its seat.

Q. Will that cut off the whole length of the stroke?

A. No, sir.

Q. Within what limits would it cut off the steam?

A. Not more than half-stroke.

Q. Did you use any contrivance to arrest the descent of the valve? 1400

A. Yes, sir; we first used a spring underneath the valve, and, after that, leather was tried immediately above the stuffing-box—a leather cushion; after that we tried air, and subsequently water.

Q. Describe the manner in which you tried air.

A. There was a cylinder of five or six inches diameter placed below the valve, and on the end of the valve-stem

1401 was a piston working in that cylinder; the air was admitted to that cylinder by means of a valve at the bottom, and formed a cushion to arrest the falling of the valve.

Q. Will you take the model and state whether that is a representation of it?

A. This model is a very fair representation of the cylinder that was used; a plain, straight cylinder, with a plate at the bottom, and in this plate was a valve to admit the air into the cylinder. As the weight descended it compressed the air to prevent the valve from slamming upon
1402 its seat—at least such was the intention, but it was found difficult to regulate it. There was a cock placed upon the side of the cylinder, to allow the air to escape freely until the valve approached its seat, but it was impossible to regulate it for any length of time, to continue in operation, because the difference in the pressure of the steam and in the height from which the valve would fall, at different points of cut-off, would prevent it from checking the valve and preventing its slamming. It required constant attention to
1403 regulate the escape of air.

Q. What was the effect of the use of air upon the valve?

A. On the valve?

Q. Yes.

A. Well, it was not available; that is, it did not answer the purpose.

Q. Why did it not answer the purpose? what was the purpose you wished to have answered?

A. To prevent the valves from slamming on their seats. The air, by a nice adjustment of the cock would do so; but it was impracticable, for all that, because it required such
1404 continual adjustment, ever varying with the pressure of the steam and weight on the engine.

Q. What was the effect of the cushion of air upon the valve?

A. Sometimes, if the cock were shut, it would cause too much rebound and lift the valve again from its seat; and, at other times, if the air was allowed to escape too freely, it would cause the valve to slam.

Q. Was that injurious, or not, to the valve?

A. It would be injurious to the valve.

1405 Q. How far did the piston descend in that cylinder?

A. It partook of the movement of the valve; that was variable according to the point at which we were cutting-off. If we were cutting-off at half-stroke the whole height would be about five inches.

Q. To what point did the weight descend in the cylinder?

A. Very nearly to the bottom.

Q. Below, or above the cock?

A. Below the cock. 1406

Q. Was the orifice of the cock closed by the descent of the piston?

A. Not tight; the piston itself was not so tight in the cylinder as to positively close it.

Q. Did the piston go below that?

A. Yes, but it did not positively close it.

Q. Where was air admitted into the cylinder when the valve was raised?

A. It was admitted by a valve in the bottom.

Q. What did you use after you used air?

A. We used water in the same cylinder in which air had 1407 been used.

Q. What alterations were made?

A. There had been a cup made previously.

Q. Put the parts of the model together.

A. There had been a cup made to fit in the bottom of the cylinder; the piston was made smaller to drop into that cup.

Q. Explain the operation of the model as altered.

A. We made a cup, which passed within this cylinder and was attached to a set screw, which passed through the bottom; into that cup a plunger was made to pass in this manner. 1408

Q. State if water was used successfully, and if so, how?

A. Water was used successfully by means of a piston working into a contracted cup in the cylinder, placed below the valve. Air was so elastic, that, if the valve was eased to its seat by compression of the air, it was apt to rebound and "chatter," as it is called; but with water, when it came to its seat, it remained there. And further, the water admitted could be regulated by adjustment of this cup, so as to ease the valve to its seat perfectly, which we were never able to do with air for any length of time.

Q. State when that apparatus was put on the *South* 1409 *America*.

A. It was put on in the spring of 1841.

Q. In what month?

A. In April.

Q. What assistance did you have, if any, in the construction of that apparatus?

A. This checking apparatus.

Q. The whole of it—tripping apparatus and checking apparatus?

A. I had the advice of Mr. Cunningham, in regard to the checking apparatus. The tripping apparatus was entirely my own device.

Q. Did you ever adopt any arrangement by which you

Hogg P

1410 could cut oft with your tripping apparatus beyond half-stroke?

A. No, sir, never.

Q. Will you show why you could not?

A. The reason is, that, by the time the piston has arrived at half-stroke in the cylinder, the lifting-rod which has been moved by the eccentric for opening the steam-valve, always shifts and commences to return; so that, beyond the half-stroke, there is no motion to trip the valve,
1411 as the movement commences in the other direction. The lifting-rod commences to return when the piston is at half-stroke; and, therefore, if the detachment is not effected by that time, there cannot then be any effected.

Q. Will you show to the jury the situation of the fork to the valve-stem, and how it operates upon it.

A. The lifting-rod being moved by the eccentric, as the piston commences its stroke, rises until the piston has arrived at half-stroke; it then commences to return. Such
1412 is the arrangement of the eccentric, that, when the piston has arrived at half-stroke, the eccentric commences to return. That being the case, if the valve is not released by the time it commences to return, from that time, on the downward movement of the rod, there is nothing to release it. The catch returns into its place, even though it had been partially removed from the stem.

On being *cross-examined*, the witness, *Peter Hogg*, testi-
1413 fied as follows:

Q. Cannot that apparatus be altered so as to make it cut-off beyond half-stroke?

A. Other parts may be added, to cause it to do it.

Q. But, as this stands, it cannot.

A. No, sir.

Q. Cannot you, by reversing that cam in some way?

A. No, sir.

Q. Were you examined as a witness here in a trial in 1843, in which this patent was under consideration?

1414 A. Yes.

On being *re-examined*, the witness, *Peter Hogg*, testified as follows:

Q. Did the defendant's apparatus, in that trial, use air or water in the dash-pot?

A. Water.

Q. Did you see the apparatus of the defendant in that case?

A. No sir.

Q. Rodman's apparatus—the defendant in that case? 1415
A. I think I have seen it.
Q. Did you know what it was?
A. Whether I did or not at that time, I do not know?
Q. Do you know how it was constructed?
A. Not internally, I do not.
Q. Well, externally?
A. Yes, sir.
Q. Do you know whether it used air or water?
A. I do not know positively—not of my own knowledge?
Q. Do you know what it was said to use, on the trial? 1416
A. It was said to use water.
Q. Did you see the construction of the tripping apparatus in that case?
A. Yes, sir.
Q. Who built it?
A. Mr. Rodman built it.
Q. Do you know in what manner he built it?
A. Similar to this model (of Sickels' apparatus.)
Q. Do you know whether it was exactly similar to that model?
A. No; I do not know that it was exactly similar.
Q. Do you know of his building one on the same plan? 1417
A. Yes, sir; I have seen many others on the same plan.
Q. Building by Rodman?
A. Yes, sir; and others.
Q. By whom?
A. I cannot answer positively as to whom. I may say I have seen some others built by them—not many.
Q. Will you state whether you stated, upon that trial, all the facts within your knowledge relating to this cut-off?
A. On that trial the facts were not all stated.
Q. Why not?
A. We were confined to a categorical answer, yes or no; and there were many questions that would have brought 1418 out other facts in the case, if they had been allowed to answer them.
Q. Will you say whether you were permitted to state facts within your knowledge respecting this cut-off?
A. I was not.

On being further *cross-examined*, the witness, PETER HOGG, testified as follows:

Q. Were you not sworn then to tell the truth and the whole truth?
A. I presume so.

1419 Q. Who prevented you from telling the whole truth?
A. The counsel on the opposite side, I believe.
Q. Who was counsel on the opposite side?
A. Mr. Seth P. Staples.
Q, Did he prevent you from telling the whole truth?
A. I cannot say that he prevented me from telling the whole truth; but there is such a thing as requiring a witness to answer a question simply yes or no, without explanation or investigation.
Q. Did you ask the court to permit you to tell the whole
1420 truth?
A. I cannot say that I did, sir.
Q. What is it you testified to on that occasion?
A. There were circumstances of the origin of this contraction in the dash-pot which I offered to state, and was prevented, as being ruled out of the case, or out of the question.
Q. That is all?
A. Yes, sir.
Q. Now, sir, do you know if the cut-off on Sickels' plan,
1421 with water, requires the adjustable cup to be shifted whenever the cut-off is varied, during its operation?
A. I do not, within reasonable limits.
Q. When shifting from cut-off short to half-stroke?
A. Yes; in most cases from very short to half-stroke, it it would require a slight adjustment.
Q. Is that the practice, now, sir, of adjusting them, when shifting in that way?
A. Is it not the practice to shift the cut-off.
Q. But when the cut-off is shifted from short to half-
1422 stroke, is it or not the practice to make a corresponding adjustment in the cup?
A. I have found it necessary myself.
Q. I am asking you whether it is the common practice among engineers?
A. I do not say what the practice of others is; I can only say what I have myself pursued.
Q. In what engines did you find it necessary?
A. I may say I have found it so on every one.
1423 Q. Name one, and who was engineer?
A. This same *South America*.
Q. Any since Sickels' patent was granted, in which you know that the cup has to be adjusted when the cut-off is shifted?
A. I have found it so in the United States steamer *Fulton*.
Q. Where is the *Fulton* now?
A. I think she is afloat yet.
Q. With Sickels' cut-off?

A. No, sir; she has a new engine now, and the old 1424
machinery has been taken out.

Q. When was it that you found it necessary in the *Fulton?*

A. In 1842.

Q. Cannot you name any of a later date than that, and give me the name of the engineer who worked the engine?

A. I have not had anything much to do with them for many years. Very few have been made by me of late. I recollect that case particularly, because Mr. Stevens had
applied his cut-off to one engine, and I had applied the 1425
drop valve to the gear upon the opposite engine, and we were seeing who could produce the best effect by cutting off, and adjusting the cut-off. In those experiments, I recollect having very frequently to adjust the cup below the valve.

Q. Who was the engineer of that engine?

A. I really do not recollect his name.

Q. Cannot you remember the name of the engineer who worked that engine during the trial?

A. I cannot.

Q. Can you give me the name of any engineer who, to
your knowledge, has worked an engine requiring that ad- 1426
justment since the date of Sickels' patent, and where the engine is to be found?

A. No sir, I cannot. The experiment is not usually made, for it is not usually required.

Q. How far was that cock in the air-cylinder from the bottom of the cylinder?

A. It was about the distance of the flange.

Q. I am asking you what distance from the bottom of the air-cylinder?

A. Immediately above the flange.

Q. Cannot you tell me how high above the bottom—the inside bottom, I mean.

A. No sir, I cannot. It was at least the thickness of the 1427
fllange—3-4ths of an inch.

Q. Do you mean to swear that it was only three-quarters of an inch from the bottom of the cylinder?

A. It might have been more than that. It was at least that.

Q. Will you swear that it was not from $1\frac{1}{2}$ to 2 inches?

A. I cannot say that it was not two inches.

Q. You cannot say that it was not $1\frac{1}{2}$ inches?

A. I cannot say whether it was $1\frac{1}{2}$ or $1\frac{3}{4}$.

Q. Can you state what was the greatest depth to which the plunger descended in that cylinder?

A. I cannot say.

Q. Now, Mr. Hogg, do I understand you to say that a dash-pot cannot be made on Sickels' plan to work with air, and prevent the slamming of the valves?

1428 A. I found it impossible to do it myself.

On being further *re-examined* the witness, *Peter Hogg*, testified as follows:

Q. You say that but few of these cut-offs have been made of late years?

A. I said that I had made but few of late years.

Q. Will you state your place of business at present?

A. At the foot of 13th street, North River.

Q. What business?

A. Manufacturer of steam-boat engines particularly.

Q. What firm?

A. Hogg & Delamater.

The defendants here rested.

1429 The plaintiffs then recalled as a witness *Henry B. Renwick*, who testified as follows:

Q. Would it be a practical way of making steam-engines on the defendants' arrangement, to have the weight for closing the valve suspended by a chain or other loose connection?

A. I should think it would not. I have had some little experience in such things.

Q. Will you state your experience?

A. Some years ago I was foolish enough to fasten a reciprocating weight to a chain, so that it rose and fell as it
1430 does in that engine, only it made fourteen strokes a minute instead of forty. It was, I believe, a one ton weight upon a ten ton chain, and I found that the weight cut the chain in two before the first twenty-four hours were out, by the sudden change up and down of the motion of the weight.

Q. If, instead of a dash-pot, a weight should be permitted to descend on pieces of carpet or leather, what would be the practical result of that?

A. Well sir, I say, as I said before, that any slam or jar upon the bed-plate of an engine would not only be transmitted to the valve, but to the whole parts of the engine. And you will notice, in this machine, by dropping it on the
1431 floor of this court-room, thus, (illustrating it,) I transfer its slam to the gas-lights in this room, and the ceiling all over it.

Q. What would be the practical effect upon the parts of the engine moving upon each other—such as the valves working on their seats, and the piston working in the cylinder?

A. I can only say generally with reference to that, that every man who is an engineer tries to avoid all concussions and jars upon the engine if possible, as every jar is injurious to the working of the engine. If an engine goes as still as a watch, without any jar, it will work better and last longer.

Q. Would it be practicable to work the puppet-valves 1432
with a trip for a short period of time, by arresting the weight with carpet, as it is arranged under that weight?

A. I have never tried it, but I do not think it would. I do not think that any body would ever try it.

Q. Do you know, sir if the valves could be closed so as to cut off steam?

A. They would probably be closed, but there would be a great slam upon the whole of the engine, and upon the valve-seat also. It would be very much the same as if the
weight fell without any carpet arrangement under it at all. 1433

Q. Now, sir, with reference to Sickels' dash-pot in connection with puppet-valves. Could air, substituted for water, work efficiently?

A. I think air might be substituted to work instead of water, but I think that water is the better fluid of the two, for the reason that a man always works with the tools which he can control easiest. It would require less adjustment and less experiment to find out the precise size of the dash-pot, in the first place. Air could be made to work, but not
so well as water. 1434

Q. Do you know how long check-rings have been used in connection with puppet-valves?

A. I cannot state. They are an old affair. I have no way of fixing the first time that I saw them.

Q. Do you know if they have been made sufficiently tight to cut off steam before the valve reaches its seat?

A. That I cannot answer of my own knowledge. I never was in the inside of a chest so as to examine and ascertain whether the fact was so or not. It would depend upon how
nicely the valve-check-ring was fitted and ground. It 1435
would cut off sufficient for all practical purposes in a large engine, for the aperture would be almost nothing.

Q. Are you acquainted with what is known as the Seaward arrangement of slide-valves?

A. I have known them for many years.

Q. Will you state to the jury whether that resembles or differs from the arrangement of valves in the defendants' engine?

A. This arrangement of valves I should consider to be substantially the same as the arrangement of valves in the de-
fendants' engine. 1436

Q. Do you know if that arrangement of valves was known at the time of Sickels' patent?

A. My impression is that they were known before, but I cannot speak with perfect certainty. I think they are described in one of the early editions of books upon the subject.

Q. Just see when that book was published, (handing a book.)

Renwick v. pl

1437 A. At London, in 1840; this patent of Mr. Corliss has got the same arrangement.

Q. Will you examine that patent? (handing one.)

A. This is a patent granted to William Garlin for an improvement in the regulating or throttle valves of steam-engines, dated October 11th, 1841.

The defendants' counsel objected to the introduction of the patent to Garlin in evidence, on the ground that it was irrelevant, but the objection was overruled by the Court, to which decision the defendants' counsel excepted,
1438 and the patent was read in evidence, with the schedule and drawings annexed to it. It was a patent granted by the United States to William Garlin, of Providence, Rhode Island, October 11th, 1841, for fourteen years from that day. The schedule was as follows:

The Schedule referred to in these Letters Patent and making part of the same.

To all whom it may concern: Be it known, That I, Wil-
1439 liam Garlin, of Providence, in the County of Providence, and State of Rhode Island, have invented a new and improved method of constructing valves to be applied as throttle or regulating valves to steam engines; and I do declare that the following is a full and exact description. The nature of my invention consists in the peculiar construction of the valve, and its connection with the stem or rod by which it is moved.

To enable others skilled in the art to make and use my invention, I will proceed to describe its construction.

1440 I construct a chamber (to contain the valve) the plan of which is shown (on the accompanying drawing) by the quadrangle a, b, c, d, at No. 1; the parallelogram e represents the plan of the aperture in the chamber, over which the valve is placed; the bottom of the chamber is concave, and the sides a, b, and c, d, are semi-circular in their elevation; a section is shown of this chamber at No. 2, f, a, and b, g, the chamber; d the valve, h the stem of the valve, passing through a slot in the rod C; a perspective view of the valve
1441 is shown at No. 3; the letters referring same as No. 2; a longitudinal section of the chambes, valve and rod is shown at No. 4; K represents the rod through which the stem of the valve passes, and by which it is made to move on its semi-circular seat either opening or shutting the aperture e; No. 5 is a perspective view; the chamber is supposed transparent, that the connection of the valve with the rod K, and its place over the aperture e, may be more plainly shown; the rod K has a slot passing diametrically through it, as shown at h on fig. A; the letters in No. 5 refer to the same

parts as the same letters do in Nos. 1 and 4. The operation 1442
of this valve is as follows, namely, the slot through the rod K must be as perfect as possible; the stem of the valve to fit into it so as to allow the valve to move freely in the slot by its gravity; the chamber should be placed (if convenient) so as to allow the valve to rest on its seat by its own weight, as well as by the pressure of the steam; thus, as the valve wears, it settles through the slot and is pressed closely to its seat, thus preventing any leakage of steam.

What I claim as my invention, and desire to secure by Letters Patent, is the manner of connecting the valve d 1443
with the rod K, so as to adjust itself to the seat (on which it moves) by the stem h passing up or down through the slot in the rod, as the case may be, the whole combined as herein set forth.

William Garlin.

Witnesses,
Fransis W. Larsin.
Charles F. Pike.

Q. Will you state whether the mode of forming the connection between the valve inside and the outside corresponds or not with the defendants'? I want to know whether 1444
the valve described in that patent, and the mode of forming the connection of the valve with any mechanism outside of the valve-chest, is substantially like or substantially different from the defendants'?

A. Substantially like it. The patent is described as having a rotating valve in this chamber, which has a slight play up and down through this stem which moves it; the same as *this* valve can have a slight play up and down *here*. 1445

Mr. Blatchford.—Is that all it describes?

A. That is pretty much all. That is the scope of the patent.

Mr. Keller.—How is the motion communicated to that valve—by a sliding or rotating stem?

A. By a rotating stem. The only difference between the two is, that Mr. Garlin makes a slot in the rotating stem, and puts a portion of the valve through it; whereas, Mr. Corliss makes a slot in the valve itself, and lets a piece in; and the rotating valve would come into that slot, so as to let the valve adjust itself and come down upon its seat.

Q. Would it be practicable to work puppet-valves on a horizontal stem, connected with a tripping apparatus for 1446
cutting off steam?

A. Yes, sir; I see no impracticability in it at all. I have seen puppet-valves worked at various angles. The

Remark re. p

1447 only point is to make your guides long enough to make the valve seat truly.

Q. In a case of that sort, in working the tripping apparatus, I think I understood you to state that it is necessary to connect a weight with it, for the purpose of closing the valve?

A. Yes; the valve, if laid horizontally, would have no weight that would tend to close it. Its whole weight would rest upon the stem.

Q. In a case of that sort, could a weight be suspended to
1448 it, as it is in the defendants' arrangement; the rod connecting with the rock-shaft arm?

A. It could be made. The easiest way to shut this valve is to prolong this stem through the dash-pot, and then to make a connection, flexible or otherwise, to a bell-crank, with a hanging weight upon the other arm. But the flexible connection *here* would be liable to the same objection as the flexible connection in *that* engine.

Q. Taking the proportion of the valves in that apparatus taken from the De Laine Mills, to what power do you think
1449 they would be adapted?

A. It is difficult to speak with certainty, for engineers vary much in their proportions. Those valves seem to be between 7 and 8 inches, and are big enough for an eighty-horse-power engine—perhaps ninety. I have seen an eighty-horse-power engine worked with similar valves to those.

Q. When the throttle-valve was first applied to the steam-engine, was it regulated by hand?

A. It was, so far as I know, or can find out by reading.
1450 It was just as it is now in many cases. A man stands by with his hand upon the throttle-valve, and watches the engine, and shuts off or gives steam as occasion requires.

Q. What change was introduced by the addition of the governor to the throttle-valve?

A. The throttle-valve, the handle and the stem performed all the same objects that they did before, and the governor was only put there to do the work of the man.

Q. To render it automatic?

1451 A. Yes. It does not render it entirely automatic.

Mr. Blatchford,—It does not render it automatic?

A. No, sir; no governor does.

Mr. Keller,—Will you examine that model (of Watt's;) what does that represent?

A. That is a model of a weight and the cylinder in which it falls, used by Watt and others for opening a puppet-valve.

Q. State in what particulars you find the dash-pot and

Puppet valve

weight to be substantially alike or substantially different 1452
from the dash-pot used by the defendants and the dash-pot described in Sickels' patent?

A. I don't think it is at all like either of them. It is described clearly enough that, as this weight descends, the passage of water from one side to the other of the weight is always the same. There is no alteration in the flow; and, as this plunger goes towards the bottom of the cylinder, it never shuts up or gradually contracts the aperture, so as to check the flow of the water; and, in all the drawings of 1453
plug-tree arrangements that I have ever seen, the weight is never brought up by the water, but is brought up by a toggle-joint in the plug-frame itself. The weight does not fetch up the valve, but the valve does the weight. In this dash-pot of Watt's I find by the drawings that the weight cannot possibly come to the bottom; and another good reason for showing why it could not have been so is, that there is a small valve opening inwards, the object of which is to let the water in, so as to raise the weight easily. If the weight fell down to the bottom, it would shut the valve 1454
so that it could not open when the weight began to rise.

Watts

Q. Will you explain to the jury the difference which you find between the arrangements used by Watt and the plaintiffs' and defendants'?

A. One single point that makes them entirely different is that in Watt's, the mechanism which moves the valve is never latched fast to the valve. The valve does not follow that mechanism. There are a series of blows hit upon the valve-gear by the plug-frame, and the valve-gear cannot be latched fast to the plug frame; for, if it were, it would tear the valve out of the valve-chest. 1455

Q. Have you any recollection from the book when the governor was first applied to the cut-off-valves of steam engines?

A. It was applied. I know, from the description of it, from 1830; I think it was before 1820; the governor has been applied and recommended to be applied to the cut-off in steam-engines in a great many different ways. This work of *Lardner's*, published in 1840, says, at page 234:

"The great advantages in the economy of fuel, resulting from the application of the expansive principle have, of late years, forced themselves on the 1456
attention of engineers, and considerable improvements have been made in its application, especially in the case of marine engines used for long voyages, in which the economy of fuel has become an object of the last importance. The mechanism by which expansive slides are moved is made capable of adjustment, so that the part of the stroke at which the steam is cut off, can be altered at pleasure. The working power of the engine, therefore, instead of being controlled by the throttle-valve, is regulated by the greater or less extent to which the expansive principle is applied. Steam of the same pressure is admitted to the cylinder in all cases; but it is cut off at a greater or less

1457 portion of the stroke, according to the power which the engine is required to exert.

(96.) Effect of connecting the Governor with the Slide.—The last degree of perfection has been conferred on this principle by connecting the governor with the mechanism by which the slide is moved, so that the governor, instead of acting on the throttle-valve, is made to act upon the slide. By this means, when, by reason of any diminution of the resistance, the motion of the engine is accelerated, the balls of the governor diverging shift the cam or lever which governs the slide, so that the steam is cut off after a shorter portion of
1458 the stroke, the expansive principle is brought into greater play, and the quantity of steam admitted to the cylinder at each stroke is diminished. If on the other hand the resistance to the machine be increased, so as to diminish the velocity of the engine, then, the balls collapsing, the levers of the governor shift the cam which moves the slides, so as to increase the portion of the stroke made by the piston before the steam is cut off, and thereby to increase the amount of mechanical power developed in the cylinder at each stroke."

Q. Do you see any difficulty in applying the governor to
1459 Sickels' cut-off?

A. I see none, sir. I have seen drawings of the different methods of applying the governor to certainly as many as a dozen different kinds of cut-off, that have been adjustable, by making the governor adjust them, instead of a man doing so by hand

Q. Suppose the governor be connected to this sector, or to a horizontal sliding-piece having an inclined groove in it?

1460 A. It would raise and lower as the governor changes its velocity. As the balls rise or fall, they would change the position of this small slide, and that would change the point at which the steam would be cut off. And, in reference to that, I would like to say, that the governor is never automatic. Perhaps I do not express myself properly; but I mean to say that the governor, and consequently the engine, must change its number of revolutions, in any of these contrivances, before it can act upon the adjustable
1461 cut-off. The engine cannot be made to move with perfect regularity, because the difficulty must occur before the governor can apply the remedy.

(Witness illustrated on the defendants' model.)

Q. Will there be any material difference in the sensibility of the governor, applied to Sickels' in the manner that I pointed out and the manner in which it is applied in the defendants'?

1462 A. I do not think there would be. With the workmanship being equal, the balance, if anything, would be in favor of Sickels'.

Q. That is, Sickels' would be the most sensitive?

A. Yes. Sickels' valves, for a given sized engine, I think would weigh a great deal less than that weight which hangs upon the valve-stem in the defendants' engine; and both valves have, in one respect, the same peculiarity, that

is, they are placed on their seats by the stem before you, 1463
and they are both relieved as soon as you commence to open them; and in that respect they are the same.

Q. That sector, or horizontal slide with a wedge-like groove, (on the black model of plaintiffs'), as a means of adjusting pieces of mechanism and holding them—is it a substantial difference, or a mechanical equivalent for the set-screw?

A. In some respects it is different, and in some equivalent. It is an equivalent so far as it holds it and allows it to be held in any given place; but it is not an equivalent so far as it moves the inclined planes when motion is communicated. 1464

Q. Does the substitution of that for the set-screw, and the connection of the governor with it, involve the original combination of Sickels' trip, or does it destroy that original combination?

A. It involves the original combination. The original combination is a combination for tripping the valve and for checking its closing. That combination remains precisely the same, whether you move that inclined plane by a governor, or whether you move it by hand, or put a screw to
move it, or ten thousand ways in which you might move 1465
that inclined plane, which would not alter the tripping of this valve or the regulation of the closing of it.

Q. Assuming this to represent a puppet-valve of sufficient size for a twenty-horse power engine, what would be about its weight, compared with one of the weights on the defendants' engine?

A. I do not know what power *this* weight is made to bear, but *this* would only weigh 3 or 4 lbs., and I suppose that this trap (defendants' plunger) weighs 60 or 70 lbs. The weight upon the catches, as far as I can see, would be
far greater in the defendants' engine than in the plaintiffs', 1466
provided one was used with these kind of valves, and the other was used with puppet-valves.

Q. Is it an advantage, in an engine, to cut off beyond half-stroke as well as within half-stroke?

A. Yes.

Q. For instance, where you have machinery that requires a great deal of power, that only requires to be worked occasionally in the course of the day, when that machinery is off you cut off shorter, and you accumulate the power in the boiler.

A. Yes.

Q. And when the time arrives for throwing on that heavy machinery, you can then work at more than half-stroke?

A. Yes, or with the same sized engine you can do a greater amount of work. A man might have an engine,

1467 cutting off at half-stroke, too small to do his work, and, by varying the cut-off a little longer, the engine would have power enough.

The Court then adjourned to January 10th, 1855, at 11 o'clock, A.M.

January 10th, 1855, 11 o'clock, A. M.

The *re-examination* of the witness, *Henry B. Renwick*, was resumed.

Q. When you examined the defendants' engine at work,
1468 did you observe whether the weight was sufficient to move the valve after the valve was closed?

A. I did, and I found that the weight was sufficient.

Q. After the weight has been checked, if it continues to move the valves, is that any evidence that the weight itself is sufficient to move the valve when closed?

A. I should think, very good evidence.

Q. Did you observe any indication of a necessity for having a weight as heavy as that which is used in the engine?

A. One of the weights that regulated the closing of the
1469 valves had a pig of lead upon it, to help it down fast.

Q. A weight in addition to the iron weight?

A. Yes.

Q. Now, sir, as, in the plaintiffs', the descending weight is checked before the closing of the valve, and, in the defendants', the valve is closed before the weight is checked, would that make any material difference in cutting off steam, in practice?

A. I do not think that the interval would be appreciable
1470 in practice, at all; as far as I could see in the defendants' machine, I am by no means certain that the weight does not check at the instant of closing, because I could not see into the valve-chest, and I do not know what marks may have been put on by the maker; the best plan is to check the weight at the instant that the valve is closed, as near as you can get it, in both cases.

Q. What is the usual proportion of the lift of a puppet-valve, relative to its diameter?

A. It should be such as to make the number of square inches in the ring which will be measured around the
1471 valve, and between it and its seat, equal to the number of square inches in the valve. For instance, a ten-inch valve would have an area of 78 inches, and ought to lift about $2\frac{1}{2}$ inches; it would, sometimes, lift further, and, sometimes less; but the right proportion is, to open sufficient for the area of the valve.

Q. The area presented by the circumference around the

rim of the valve, multiplied by its height, should represent the number of square inches equal to the hole in the port? 1472

A. Yes.

Q. Is there any difficulty, in working puppet-valves, in admitting steam with sufficient rapidity at the time of starting?

A. No; you could shape your toes to let your steam on just as you pleased; in some large engines, they put the steam on too fast, and have to alter the toes, not to lift the puppet-valve quite as swiftly.

Q. Now, working with an air dash-pot, instead of a water 1473
dash-pot, which would be most likely to be injured in its working, by dirt clogging the parts?

A. The air dash-pot is much more liable to injury, as I saw it upon the defendants' machine; the dash-pot is close to the floor, and has that little aperture in the bottom, and, also, a little hole in the side; and, as the plunger or weight comes up, it is apt to draw up small particles of dust, shavings or dirt; the person working the engine spoke of annoyance from that cause, and I saw a strong current from the room into these little holes.

Q. Would it be likely to clog the working of the 1474
plunger?

A. Yes.

Q. Are you acquainted with the two patents granted to Corliss, and put in evidence here?

A. I have examined them both in the Patent Office.

Q. Will you state whether the patent of 1849, re-issued in 1851, relates to the mode of applying the governor, as arranged in this model here, (defendants'?)

A. No, sir, not at all like it.

Q. Will you point out to the jury how it differs from that in the defendants' machine? 1475

[Witness compared the drawings attached to the patents with the model of the defendants' apparatus, and illustrated the difference.]

Q. Does that drawing describe and represent the wrist-plate for moving the valves, as represented in the defendants' model?

A. Yes, substantially the same as it is here.

Q. Are the lifters, in the form of hook-rods, for the purpose of engaging and disengaging the valves? 1476

A. No, sir, there is nothing of that kind.

Q. Then, in that patent, the motion which is imparted to the lifters by the wrist-plate, has nothing to do with the disengagement of the catch for tripping the valve?

A. No, sir.

Q. Now, sir, looking at the second patent granted to Corliss, what was that for?

Purwick 28

1477 A. It says: "My improvement has reference to that "class of cut-off-valve motions, in which the connection be- "tween the valve, and the eccentric or the equivalent "thereof which opens the valve, is broken, to allow the "valve to move independently of the eccentric, and close "its steam-port before the piston has completed its stroke; "and my improvement consists in effecting this disconnec- "tion of the valve and the eccentric-gear, or the equivalent "thereof, by imparting to the lifting-rod a lateral move-
1478 "ment, which is limited and controlled by an adjustable "stop and spring, so that the lifting-rod not only performs "the duty usually imposed upon it, of opening the valve, "but also performs the office of a catch or latch, in con- "necting and disconnecting the valve with the eccentric- "gear."

Corliss

Q. What I want to know is, whether the wrist-plate, with the connecting-rods or lifters, is not to be found in both those patents?

1479 A. It is.

Q. In which of the patents is it that those lifters are modified with a view to disengage the valves and trip them?

A. The lifters are modified so as to disengage the valve, in the second patent; the drawing, in the second patent, is substantially like the engine of the defendants.

Mr. Blatchford: The drawing in that patent is substantially like this model?

A. The valve-gear is substantially like it; the valves are
1480 Seaward valves in the drawing, and there is an arm inside of the valve-stem, to take hold of the valve; but the arrangement for cut-off is substantially the same.

Mr. Keller.—Q. It is applied to straight slide, instead of rotating valves?

A. Yes.

Q. In either of those patents is there any claim to the dash-pot working with air?

A. No, sir. The air dash-pot is described in the second
1481 patent, if I remember right.

Mr. Blatchford.—Q. There is no claim to it in either patent?

A. There was no claim made to it originally, and certainly there was none granted, for there is none here. There is no governor mentioned in the second patent. It may be in the description: "This sliding-rod *G*, in the ex- "amples represented in the drawing, is constructed to be "moved by hand, through the intervention of a rack *n* "and worm *p;* the last of which is turned by hand, to "screw up or screw down the sliding-rod; but the sliding-

" rod *G* may be moved by the engine itself, by connecting 1482
" it with the slide of the governor, so that as the latter is
" moved, the point at which the cut-off is effected will be
" varied."

Mr. Keller.—Q. When that sliding-rod is moved up and down, with a screw, by hand, will it regulate the engine?

A. Yes.

Q. I mean would it be an automatic regulation?

A. No, sir; because a man will have to stand there and move it. An engine will cut-off just the same if you put a man there instead of a governor. The hook-rod arrange- 1483
ment for lifting and tripping the valves and closing the port will be the same.

Q. How will the regulation in that respect differ from Sickels'?

A. It would be just the same.

Q. With regard to the patent put in evidence yesterday, granted to Sickels in 1845, will you explain to the jury any difference that you find between the black model of Sickels' apparatus, furnished by the plaintiffs, and the mahogany model produced by the defendants, so far as 1484
regards the action of the springs upon the adjustable slide?

A. On this mahogany model, this valve-stem is not sufficiently wide; and, when the springs are open, and held apart by the stem, it does not hold them sufficiently far apart to permit the springs to clear the inclined plane upon the downward stroke, which would give a slight check to the governor; but, in Sickels' arrangement, as shown on the black model, the valve-stem is wide, and, when the valve is tripped, the springs do not touch the inclined plane. 1485

Q. Will you explain to the jury from this model, and the patent of 1845, what the feature of that invention is?

A. The best way would be first to show what the difficulty was. We will suppose, in this model of Sickels' (and I think the same feature will be found in Corliss',) that we want to cut off just before we get to half-stroke. In that case, if I shove this inclined plane up so as to cut off just before we get to half-stroke, it may happen that I will not throw the springs out far enough. In order to get rid of that difficulty, Mr. Sickels contrived this plan, by which 1486
he knocked the latch out, or the spring which opens the valve, the same as in this from the De Laine Mills, which latches the spring fast to the lifter.

Q. What was the patent of 1852 granted to Mr. Sickels for?

A. That was granted for a different way of getting over the same difficulty. In balanced puppet-valves the chief

Renwick
Re D P2

1487 power is required to move them at the moment of starting, and of course the latch that would hold it well after it is first started might be made so delicate that it would not start. Mr. Sickels made the latch strong enough to start the valve from its seat. Just after the valve was started he shoved the latch out a little way, and left it then to hold in just enough to support it; so that the travel across the inclined plane would knock it out, and enable him to cut off at half-stroke.

Q. Are these two patents of Sickels' for the same inven-
1488 tion, to apply the same purpose, as the patent of 1842, or for an improvement upon it?

A. They are for improvements. I have always considered them upon that plan—to arrive at ways of unlatching, to get over certain difficulties.

On being *cross-examined*, the witness, HENRY B. RENWICK, testified as follows:—

Q. Were you Examiner in 1845?

A. No.

Q. Were you in 1849?

A. Yes.

1489 Q. In 1851 and 1852?

A. No, sir, I think I left in January, 1852 or 1853.

Q. Were you Examiner when this patent of Sickels of 1852 was passed?

A. Yes; in 1853 I must have left.

Q. Do you consider the difference between the apparatus described in the patents of 1842, 1845 and 1852 substantially sufficient to warrant the granting of patents for those subsequent descriptions?

A. Yes. The patent law says——

Q. I ask you your opinion?

A. And I have given it. I will tell you my reasons. The patent law says we must patent original inventions and all improvements thereon.

1490 Q. Is there anything in these patents of 1845 or 1852, as to their being improvements upon the invention of 1842?

A. I do not know, but if you will hand me the patents I will see.

Q. You can do that presently. Were you acquainted with the patents granted to Sickels while you were Examiner?

A. Yes, sir, I was.

Q. I want to know if you knew of them in 1849, and were acquainted with them?

A. I could not know the patent of 1852 in 1849.

Q. I mean the patents of 1842 and 1845?

A. Yes. 1491

Q. I will ask you if this model does not represent the apparatus described in the Corliss patent of 1851, connecting the slide with the slide of the governor?

A. No, sir, there is no representation in the patent?

Q. I say the model?

A. It represents the same apparatus—not with the slide, but with the governor.

Q. Do you find in the Corliss patent of 1849 any description of slides or cams, connecting with the sliding sleeve of the governor, which do not revolve? 1492

A. I think there is.

Q. Will you read it?

A. It is as follows: "I do not limit myself to the use of "the particular kind of cams described or represented; as "the form, position, and operation of these may be greatly "varied without changing the principle of this part of my "invention; as, for instance, stops or cams connected with "the slide of the governor by levers, may be made to slide "in the direction of the plane of motion of the valve-rods, "to vary the periods of liberating the catches of the valve-"rods; or wedge-formed stops or cams may be substituted 1493 "for the helical cams, and attached to the cam-rod, which, "in that case, must not turn."

Q. You say that dirt and other substances may be thrown into the air-reservoir. Do you find no difficulty in the use of water in the water dash-pot?

A. I have never found any, sir.

Q. Will not the water evaporate soon?

A. It could not very well get out of the pot, because it is shut up tight.

Q. Is it always shut up tight? 1494

A. In all the dash-pots that I have seen.

Q. Is it not placed near the engine, in a warm position?

A. Yes, but you cannot get steam out of the dash-pot, for there is no hole for it to get out of.

Q. Is there not a hole constructed in the side of the dash-pot?

A. Yes, but it is shut. In the general arrangement, as I know them, the dash-pot is tight and placed above the valve. There is a tight stuffing-box below.

Q. And the dash-pot, as constructed upon the black 1495 model—where is it placed?

A. That is placed under the valve; I cannot see, in this model, whether there is a stuffing-box, or not.

Q. Will not steam sometimes pass through those stuffing-boxes?

A. Yes; but there will be always less pressure in the dash-pot than there is in the boiler; and the steam would tend

1496 to come into the valves, and let water in instead of letting it out.

Q. Would it not fill it too full?

A. No.

Q. You do not think it necessary to have it, then, only two-thirds full?

A. I do not think that a special distance of height has anything to do with it.

Q. Have you ever known one long in practical use?

A. In reference to your previous question I would say,
1497 that I never opened one to look in, to ascertain exactly how high the water was.

Q. Do you know practically whether engineers find difficulty in the use of them, or not.

A. I do not think they do now.

Q. Do you know practically?

A. I cannot say practically, because I have not looked into them; but I have not heard any complaints, and I am in the way of hearing these things every day.

Q. This air cylinder of Corliss' is placed, of course, near
1498 the engine?

A. Yes.

Q. Then, dust or other substances that would be drawn into the cylinder would also get into the working parts of the engine—would they not?

A. There is no current to draw them into the working parts of the engine, but there is into the dash-pot.

Q. Could it not be covered to prevent that?

A. As I have seen it practically arranged; I limited my answer especially to that point.

1499 Q. Would it not be negligent in an engineer to suffer substances to be drawn up?

A. No, he cannot help himself. In Corliss', as I have seen it working, there is nothing to prevent substances being drawn up?

Q. Do you think it the duty of the engineer to keep the engine in order, and all the working parts of it?

A. Yes; his duty would lead him to clean it out after any stuff got into it.

Q. You say that you think the weights cannot be worked
1500 with straps or chains, or connections that are not rigid?

A. Practically, yes, sir.

Q. Do you know whether the weight was ever so worked in an engine?

A. I do not know of any weight having been so worked, until one of you gentlemen spoke of a boy who fastened strings to open the valves.

Q. In an engine of Watt's?

A. I do not know in Watt's, precisely. Strings were

first used to open the valves, but they got rid of them and 1501
put in a solid plug frame very soon after.

Q. I am speaking now of the weights attached to the arms, which, in the model we have here, serve to open the valve. Will you read this description from *Farey*, page 529?

A. It is as follows:

"In Mr. Watt's first engines, the rods 4 and 15, to which the weights of the working-gear are applied, were connected at their lower ends, with the ends
of horizontal pieces of wood, the other ends of which rested upon centre pins, 1502
in the manner of horizontal levers or like the treadles of a loom; and large iron weights were applied upon the treadles, to aid their own weight in drawing down the rods 4 and 15, in order to open the valves; these weights could be moved along the treadles, to a greater or the lesser distance from their centres of motion, so as to act with any required degree of force upon the working-gear.

These treadles were placed beneath the floor over the condensing cistern, and check-straps were applied to them, to limit the distance to which they should fall, and consequently to regulate the extent of the opening of the
valves. The lower ends of these check-straps were passed through loops, 1503
which were fastened to the treadles; and the upper ends of the straps were passed through similar loops, which were fixed to the posts for the working-gear, as is shown in the sketch, p. 524; the ends of the straps were united together by buckles, by which the lengths of the checks-traps could be regulated at pleasure, in the same manner as the stirrups-leathers of a saddle are adjusted. The check-straps were intended to stop the motion of the falling weights, and avoid noise or concussion; but a better plan, called the plunger weights, was afterwards adopted." 1504

Q. Does not that describe the use of check-straps for the purpose of arresting the weights?

A. No, sir; there is no detaching by check-straps.

Q. Does it not describe the use of check-straps, for the purpose of arresting the weight that holds the valve?

A. It describes a strap for stopping the weight as it is falling. The weight is connected with the valve by a rigid connection, and not by a strap on one end of a lever. The weight falls into a strap. The strap was intended to answer the same purpose with that carpet machine.

Q. Does it not describe the use of a strap, for the purpose of checking the weight?

A. The weight falls into the strap. 1505

Q. Will you examine plates 11 and 13 of *Farey*, and say whether they represent a valve-gearing similar to that upon Watt's model?

A. No, sir; I do not see any valve-gearing here. There are different forms of plug-tree cut-offs, but I do not see anything like that in the model. I expect it is more clearly represented in *Tredgold*.

Q. (Handing diagram,) Here is a copy from *Tredgold*.

A. That is correct, with the exception of the water-mark.

Q. Is the weight represented as falling, in the plate of *Farey*.

1506 A. I cannot tell without reading the description. It depends upon whether the port is now open or shut.

Q. Is there any dash-pot represented there?

A. No, sir; I do not see any sign of one.

Q. You stated yesterday, that you thought this valve-gearing of Watt could not be used upon an engine making more than seven to ten revolutions a minute.

A. I said it could not be used to any good effect. This kind of valve-gear in Watt's model is entirely out of use, except in slow pumping machines. It has been abandoned for probably fifty years.

1507 Q. Do you consider this, as represented upon plate 11 in *Farey*, as substantially the same?

A. It appears to me so. I cannot tell, without going into a minute examination of it.

Q. In plate 11 it was a rotating engine?

A. Yes. Watt, as soon as he began to move his engines with speed, got up a different kind of valve-gear.

Q. Will you look at page 461 of *Farey*, that refers to plates 11, 12 and 13, and read the paragraph describing the invention of that engine?

1508 A. It is as follows:

"At the first commencement of the action, the piston moves but slowly, because the inertiae of the fly-wheel, as well as the resistance of the mill-work, is opposed to the motion; but as the action goes on, each succeeding half-stroke is performed in less and less time, giving the fly-wheel an accelerating velocity, until, in about three or four strokes, the full velocity will usually be attained, and then the motion of the fly-wheel continues to be nearly uniform. In a 10 horse engine, this motion is at the rate of 25 strokes
1509 per minute, and the fly-wheel makes 50 revolutions per minute; a 20 horse engine makes 21 1-2 strokes per minute, and the fly-wheel 43 revolutions per minute; and a 40 horse engine makes 17 1-2 strokes per minute, and the fly-wheel 35 revolutions per minute."

Q. In Seaward's slides were not the steam and exhaust valves connected together?

A. I think not altogether. I think I have seen a drawing of them, where they were moved by four independent rotating cams. They were moved in different ways.

Q. As represented in *Tredgold* are they not?

A. That I cannot tell you until I see it.

1510 Q. You do not remember the way in which they moved?

A. No; I know they have been moved in different ways.

Q. In the extract which you read from *Lardner*, did you find anything said about the connection of the governor with Seaward's slide?

A. If you will give me the extract, I will see. I think it follows the description of Seaward's slide.

Q. Is it not just the other way? Does not Seaward's

slide follow the description of effecting a connection with 1511
the governor?

A. It does here. I think it was from a different page I read yesterday.

Q. You spoke of the cut-offs with which the governor was connected. How old were those that you had in your mind?

A. To the best of my recollection they were certainly before 1830. I think I knew of others before 1820.

Q. Were all that you had in your mind, previous to
1840? 1512

A. I think they were. I am not certain about that, because there were several of them in one number of a magazine. They were previous to 1849, when Corliss' first patent was granted; but whether it was 9 years or not, I do not know.

Q. You were acquainted with them as early as 1849?

A. Yes.

Q. Do you refer to the descriptions in the old books?

A. Yes.

Q. Will you name one of them? 1513

A. One was described in a number of *Newton's Journal*, by Church, in which the valve acted upon was a sort of disc-valve, that is, it was a slide-valve, turning in that way (illustrating.) There is a description in one of the early editions of *Tredgold*, where the governor acts upon the puppet-valve.

Q. Whose invention was that?

A. That I cannot say.

Q. Was it known as Field's valve?

A. That I do not know. I cannot tell you now. If I 1514
had that edition of *Tredgold*, I could find it. There is one described in the *Publication Industriel*, in which there are four Cornish crown-valves.

Q. These effected an adjustable cut-off?

A. Yes.

Q. Have you seen a check-ring made so tight that they would sometimes stick up and not work as they ought to?

A. No.

Q. Have you ever seen them in operation?

A. I spoke yesterday about that. A man cannot get
inside of a steam-chest, when the engine is going. It is 1515
very difficult to tell about those things.

Q. Is there not some mode of detecting the operation of these valves?

A, Yes.

Q. I refer to that.

A. Yes; they may be so made, but I have never seen one.

1516 Q. In this patent of William Garlin that you examined yesterday, do you find any description of the steam-valve?

A. That patent is very badly drawn. He calls it a throttle-valve, I think, throughout. I did not read it with remarkable care, but will do it if you wish me.

Q. "A new and improved method of applying valves as throttle-valves to steam-engines"?

A. Yes, sir.

Q. Will you illustrate that upon the model?

(Witness illustrated.)

1517 Q. Will you read this description, and see what he calls a stem?

A. He calls that piece that sticks up through the slot *here* (showing it.)

Q. This piece, if this were solid?

A. Yes.

Q. Suppose the solid piece represented by that which is now open, and the sides taken away—is that what he calls a valve-stem?

A. Yes.

Q. What name is given to the rod through which the
1518 valve-stem enters?

A. He calls it in the first part of the patent "rod C."

Q. What does he call it in the claim?

A. "With the rod K." He calls it "rod K."

Q. Do you find any other name?

A. He says: "What I claim as my invention, is the manner of connecting the valve d with the rod K, so as to adjust itself to the seat (on which it moves) by the stem h passing up or down through the slot in the rod, as the case
1519 may be, the whole combined as herein set forth."

Q. That corresponds with *that* rod in the defendants' model?

A. *This* is what he would call a rod.

The Court.—The rock-shaft.

A. Yes, sir. It performs the office of the valve-stem, and I should call it so.

Mr. Jenckes.—Q. In the tin model, (of Watt's dash-pot,) is the position of the valve correctly represented?

1520 A. If you give me the drawing, I will be able to tell you. (Inspecting the drawing.) Yes, it it as near as it can be on such a rough model.

Q. Do you understand that there is no more than one aperture described in *Tredgold?*

A. I do, sir.

Q. Will you read the description on page 224, vol. 1, of *Tredgold?*

A. It is as follows:

"A weight *w*, sufficient to overcome the friction and open the valve, acts 1521
by a short arm *a* on the axis, which requires to be turned to move the valve: the weight is kept suspended by a spring-catch *b* while the valve is close, and when the catch is disengaged by the handle *c*, being moved by the tappet *d*, the valve opens. If the valve be large, it requires a considerable weight *w* to open it against the pressure of the steam; and in that case, either the valve described in art. 442, or Watt's mode of relieving the pressure, may be adopted. It will naturally be inquired, why weights are raised to open the valves instead of using the direct power of the beam. The only reason assigned for so doing is, that a weight opens a valve more rapidly, and the loss by closing 1522
them slowly was not quite so readily detected; though the absolute loss is about the same, and the practice is becoming more common to open them by direct action.

The descent of the weight which opens a valve is regulated by an ingenious method; it either descends into, or forces a piston into a vessel of water, (see C, Fig. 3, Plate IX.) while the aperture by which the water escapes from under it may be increased or diminished at pleasure; the weight, therefore, acts with its full force to open the valve, but as soon as it begins to move, it is retarded by the water, till it be finally stopped. During the ascent, a 1523
valve opens inwardly at the bottom of the vessel, and therefore the engine has not more than the weight to raise again."

Q. What aperture do you understand to be first referred to?

A. I understand he first commences by stating that there may be either a plunger—he says a weight—to descend into the vessel of water itself, or it forces a piston into that vessel of water. He gives you two alternatives to go upon. Now, the well-known definition of a piston is, that it is to fit the vessel tight in which it moves. If the weight itself des- 1524
cends into the vessel, the water escapes around the sides; and if a piston is so tight below the weight that the water is, in fact, a piston, then he is obliged to make a hole. He does not speak of two holes.

Q. Where is the position of the valve indicated in the latter part of that description?

A. At the bottom of the vessel.

Q. Do you understand that description to refer to the position of the valve in the middle?

A. I suppose it does.

Q. Read the description from *Farey*, page 530. 1525

A. It is as follows:

"*Plunger weights for opening the valves*, are cylindrical weights of cast iron, which are fastened upon the rods 4 and 15 of the working gear, so that the central line of the weight corresponds with that of the rod. Each plunger is fitted into a short hollow cylinder like that of a pump barrel, which is fixed down in the condensing cistern, beneath the water. The lower end of each barrel is closed, but the bottom has a hole through the centre of 1526
it, which is covered by a leather clack-valve opening upwards. This clack will admit the water freely into the barrel as the plunger-weight is raised upwards in it, whilst the valves are closing; but when the plunger is left to fall suddenly by its own weight, in order to open the valves, the contained water must make its escape out of the barrel. The plunger does not fill the barrel very exactly, but a sufficient space is left to allow the water to squeeze out

1527 around the plunger on all sides as it descends; and so much resistance is thus opposed to the descent of the plunger, as will give it a suitable motion for opening the valves quickly, and yet without noise or concussion. This method allows the plunger-weights to be made so heavy that they can have no chance of sticking or failing to open the valves; and yet they will act quietly, and without shaking and deranging the working gear."

If you take the description from *Farey*, it will be *there*.

Q. With the description of a valve opening inwardly at the bottom of the vessel, and of the aperture by which water escapes from under the plunger, do you think it
1528 would require invention to construct a dash-pot with a valve at the bottom and at the side?

A. I wish to state first what I stated before, that there is no account of a valve and an aperture in this book. If you make Watt's dash-pot exactly like Mr. Corliss' or Mr. Sickels', of course there would be no invention in making Sickels' or Corliss'.

Q. Taking that description, may it not indicate a valve in the bottom, through which the water enters, and an
1529 aperture through which the water escapes?

A. No; because he gives you two alternatives—one is the piston, and the other the plunger. There is to be a passage around the plunger and below the piston.

Q. Do you think it would require invention, after the description just read, to make an aperture there?

A. I do most certainly, if, in closing that aperture by the descending weight, you increased the resistance.

Q. How do you understand that aperture may be increased or diminished at pleasure?

1530 A. I suppose when he conceived a piston fitting tight, so as no water could escape, and added a weight upon the top of that piston, he had a hole at the bottom, with a cock in it.

Q. Would you not get that idea from the description, if a piston were used?

A. If a piston were used, they would have an aperture at the bottom.

Q. And you would get that from *Tredgold?*

A. Yes.

Q. Do you think it would require any invention to put a valve in the bottom, after the description in *Tredgold?*

1531 A. I think not; but you would not then have Sickels' dash-pot.

Q. In case of an aperture through the side of a vessel, like this, to permit water to escape freely, would not the piston or plunger descend freely during the first part of its descent?

A. If you confine your question to either the piston or plunger, as they act differently, I will give you an answer.

Q. Take a weighted piston?

A. If you have a tight piston moving in this vessel of

water, and the water escapes freely through that hole as the 1532
piston comes down, the piston will descend with slightly increased force, forcing the water out of the hole.

Q. Suppose you make a hole large enough for the water to escape freely?

A. Then the water would escape fast.

Q. If you put a hole at the side, would it take invention to do it?

A. Yes. You would make it a totally different machine.

Q. You think that would require invention?

A. Most certainly.

Q. Suppose, now, you alter the level of the water in that 1533
vessel, so that instead of the piston being continually immersed it should be made longer, and rise above or just to the surface of the water, what would be its operation during its descent?

A. If the piston rises above the surface of the water, when it gets down to the water there would be a sudden blow and jar, and then it would go down just as it went down in the first instance.

Q. Suppose it to be raised so that the bottom of the piston
would be just immersed in the water? 1534

A. Then it would force the water out just as a pump throws the water out.

Q. Would it not fall freely through the first portion of its descent?

A. Not the piston.

Q. Suppose it to be a plunger.

A. Then the water would escape around the plunger, and not go through the hole.

Q. I am supposing no hole at all. Would it not descend freely through the first portion of its descent?

A. Probably it would go in freely until immersed, and 1535
then the density of the water would affect the weight of the plunger.

Q. Suppose you make the plunger very long in proportion to its diameter, and then elevate it?

A. You increase the friction of the discharge around it. Instead, then, of falling to a certain point, as it does in Sickels', and then being gradually checked, it would fall slower, slower, slower all the time.

Q. Would it acquire no momentum in its fall through
the air? 1536

A. Yes.

Q. Would not a portion of it fall through the air?

A. Yes.

Q. Would it not acquire momentum?

A. Very little.

Q. Would it not depend upon the length of your plunger?

1537 A. Yes.

Q. You might thus obtain a rapid descent?

A. Not very much, because it would be checked in the water.

Q. Would it be checked before the weight was entirely immersed?

A. Yes.

Q. To a sensible degree?

A. Yes. It would check more and more all the way.

Q. You might make a plunger and its barrel so that this checking would not commence until the valve was entirely
1538 opened or closed—could you not?

A. I could make a dash-pot out of that like Sickels'.

Q. Do you think a simple alteration of the size and form of the plunger would be substantially an alteration in Watt's dash-pot?

A. No.

Q. Now, in altering the barrel and plunger and altering the level of the water, might you not produce the effect of a rapid descent at first, and then check it until the weight is brought to rest?

A. If you will alter the form of the weight and make it
1539 fit the barrel tight, and only put a little water in the bottom, we shall have but little escape afterwards; and then, by letting it fall through the air, and come to the bottom, like Sickels' reservoir, you can check it; I do not think you could check it materially; it would keep on moving.

Q. I am not supposing it to be raised above the water, but to the surface of the water, so that you would have a difference in the specific gravity?

A. It would then fall faster at first, I do not know that it would fall much faster, until it became immersed; then
1540 it would commence being retarded, and be retarded slower and slower until it got down.

Q. Would it require invention to alter that barrel to effect that purpose?

A. It might, or might not; by altering the level of the water, if you could perform an important purpose, it might make it an invention.

Q. In the model of Watt's gear, I think you stated that this contrivance shows only a mode of opening the valve?

A. Yes.

1541 Q. Read the description in *Farey*, page 457?

A. It is as follows:

"The valves must be opened and shut by hand, in order to stop or start the engine, or to regulate its motion; and for this purpose the attendant always retains a full control over all the four valves, by means of the two handles *r* and *s*, either to open or to shut either pair of the valves, whatever position the chocks 1 or 2 of the plug may be in; for even when either of those

chocks has moved the handle belonging to it, so as to shut one pair of valves, 1542
they may nevertheless be opened again immediately, by the same handle, without waiting for the return or removal of the chock from that handle. This is done by moving the handle still further in the same direction as the chock has just moved it; for when the valves are shut, the short levers on the axes of the handles, being in the lines of their connecting rods, those levers will have the effect of opening the valves, when they are turned in either direction from that position. In the regular action of the working-gear when moved by the chocks, the valves are closed by the motion which those chocks give to the handles; and are opened again by the fall of the weights 4 and 1543
15; nevertheless, when the engine is regulated by hand, that action may be reversed if required; for the same effects may be produced by the contrary motions of the handles; and then the weights will tend to close the valves, intead of to open them."

That description, so far as I understand it, refers only to working an engine by hand, just the same as in a steam-engine, where it is worked by hand instead of letting the eccentric do its work.

Q. Look at the description in *Stuart*, vol. 2, page 366.

A. It is as follows: 1544

"The different construction of Watt's valves required a new arrangement of the hand-gear to move them. In the atmospheric engines, the weight or tumbling bob at the end of the levers, called the Y piece, was placed there, so that its fall should open the sliding valve, or the injection cock, with a jerk; it exerted no influence whatever in keeping the valves in their places, at least, it was not introduced for that purpose. Watt also sometimes attached a weight to the spanners, which opened or shut his valves."

Q. Does it not refer to the description of a dash-pot and 1545
plunger?

A. (Witness continued reading.)

"But it was necessary in some arrangements of these parts that they should be gradually shut, to prevent the injury that would be occasioned by a sudden jerking of the valves into their seats. This weight was, therefore, sometimes formed like a piston, which rose and fell in a cylinder filled with water. The weights, or plungers, were made of cast-iron, and cylindrical, each fitted into a hollow cylinder, placed in the condensing cistern, and covered with water; the plunger is made somewhat less than the barrel, to allow a small space, by which, when it descends, the water may rise between it and the barrel; the lower end of each barrel is closed, except a small hole, which is 1546
covered by a leather valve opening inwards. When the plunger is drawn up, the water from the cistern flows through this valve into the barrel, but when the plunger descends, the valve closes, and the water which is displaced rises between the plunger and barrel, and the resistance which is thus occasioned to the descent of the weight prevents the concussion which would be produced by its uninterrupted fall, and at the same time affording a means of making the weight sufficiently heavy to open the valve."

Q. Look over the description yourself, and see if it does not refer to the steam-valves?

A. It may; the valve spoken of directly before is an injection valve.

Remark re

1547 Q. Do you know of any method indicated in the books, by which you can check the action of the weight by the valve?

A. No.

Q. Do you think it would require invention?

A. Not if Watt had told you how to do it.

Q. Do you find he has told you?

A. He does not say anything about closing the valves.

Q. Look at *Farey*, page 457?

A. I cannot make head or tail out of *Farey*, for he is excessively obscure; I could do such a thing myself, but I
1548 would not be guided by his description.

Q. Would you have to alter essentially the arrangement of those parts?

A. Very considerably.

Q. Do you think those alterations would be substantial alterations?

A. It would depend upon what they would be, after I had drawn them out; I cannot tell now what I would have to do, but I know I could do it.

Q. In looking at the models and reading the descriptions,
1549 you see no method by which it could be done?

A. I see no method described; as long as the plug-frame descends, it opens the valve, and, as the plug-frame ascends, it shuts the valve.

Q. Suppose we have a piston and cylinder constructed like *this* drawing, with a valve opening inward from the bottom, governed by a cock, and allowing the diameter of the cylinder to be $2\frac{1}{2}$ inches, would it not give 5 inches area?

A. About $4\frac{1}{2}$ inches.

1550 Q. Take a weight twice the weight of the pressure of the atmosphere, what would be the effect of the descent of that weight or piston for the first half of its stroke?

A. Would you open or shut the cock while the weight is coming down?

Q. Keep it still.

A. And what is the cylinder to be filled with?

Q. Air. How far would it drop down freely?

A. It would not drop down freely.

1551 Q. Would it not compress the air into half the space it occupied before?

A. No, because air would be going out of this hole.

Q. Would it fall freely beyond half its distance?

A. No; it is like a boy's common squirt.

Q. I am speaking of air?

A. It would squirt in the same way.

Q. Would not the compression of the air be instantaneous?

A. No. 1552

Q. Can you measure the space of time of retardation?

A. I could not do that.

Q. Suppose the escape of air were sufficient to counteract the resistance of the air, would the weight not fall freely?

A. If you will suppose that hole to be large enough to counteract the pressure, the weight will. As soon as the air got compressed sufficiently to pass out through here as fast as the plunger descended, the plunger would then go down with uniform velocity, and it would be gradually re- 1553 tarded—how much or little I cannot say—until it got to that uniform velocity.

Q. Until it came to that point how would it move?

A. It would be gradually retarded.

Q. Do you mean just the same proportion at the commencement of its stroke that it has towards its end?

A. It would be retarded in the inverse of a hyperbolic curve.

Q. Have you known in practice an engine constructed so that the puppet-valves moved horizontally? 1554

A. I said that I had seen the old *Novelty* with puppet-valves moving horizontally; and in the oscillating engines now constructed at the Novelty Works, in which the valves are cast fast to the cylinder.

Q. Was not the *Novelty* an experimental boat?

A. It ran several years, which is rather long for an experiment.

On being *re-examined*, the witness, HENRY B. RENWICK, testified as follows: 1555

Q. Do you find any description of these various modifications pointed out to you, of Watt's valve-gear and dash-pot, in the books?

A. No, sir.

Q. In case this (in Watt's model) should be reversed, so that the weight will close the valve, state whether the weight or toggle-joint would gradually arrest the valve?

A. The lead on the toggle would stop it.

Q. This is just the same as a crank arrests the momentum of an engine. Do you find any description in the books of 1556 the manner in which an engine is to be arranged with a view to close the valves by a weight?

A. I have looked very carefully, and I do not.

Q. I will call your attention to Sickels' patent of 1845, as the counsel did not do it. Just read that passage of the specification, and state whether that indicates a limitation of the invention contained in that patent, as an improvement upon previous inventions?

1557 A. Mr. Sickels describes first his old patent, and then says, that the object of his invention is to remedy the defects in that old machine.

Q. Will you look at this passage in Sickels' patent of 1852, and state whether that indicates a limitation to an improvement?

A. It does, very clearly.

Q. Read the language?

A. It is as follows: "In cut-offs, as heretofore constructed, in operating the catch by the closing movement alone,
1558 the valve cannot be tripped, until sufficient motion has taken place to operate the whole extent of the catch, thus occasioning an unavoidable delay in tripping the valve. The nature of my invention, therefore, consists in operating the catch or hold, and liberating the valves of the trip cut-offs on the movement to close or return of the valve-motion, by means of an adjustable cam or lever, after it has been partially operated upon on the opening movement of the valve-motion, so as to leave as little movement of the catch
1559 to affect the liberation of the valve, as may be desired, to be accomplished by the return movement; thereby being enabled to liberate the valve, and cut off the steam, as near the first of the return movement as may be desired."

Q. In the hypothesis that was put to you of a long plunger gradually entering the water, to retard the descending weight—where it starts merely resting upon the water and is gradually immersed—in the range of motion necessary for the working of valves by a descending weight of that
1560 sort, is there a sufficient length of motion practically to develop the law of the mechanical retardation of forces?

A. No.

The plaintiffs then re-called as a witness *Daniel Barnum*, who testified as follows:

Q. Did you, at my request, make a model of an arrangement of the defendants' tripping apparatus, with a view to regulate cut-offs beyond half-stroke, as well as within half-stroke?

1561 A. I did, sir.

Q. Is this the model?

A. Yes.

Q. Just explain to the jury how it regulates, so as to cut off?

A. I have three different methods in this model of doing it. One is an arbitrary method of doing it, by independent motion; one is an arrangement similar to that shown in the defendants' model; and one is by another arrangement. (Witness illustrated and explained.) All the regular changes may be made of cut-off at any point, with the same arrangement.

Mr. Blatchford.—Precisely as it is *there?* 1562

A. Not precisely like that in the defendants' model, but with additions I have made.

Mr. Keller.—In making that addition, did you change any of the arrangement of the defendants for cutting off, or did you simply improve the defendants' arrangement, by an improvement, to enable it to cut off beyond half-stroke, in addition to cutting off within half-stroke?

A. It was an addition superadded to the defendants', of course.

Q. What length of time did you take to make that improvement? 1563

A. I did it in an evening, with a jack-knife

Q. I will call your attention now to the hooks upon the lifter-arm and their engagement with the lifter, and I will get you to state whether, as represented in the defendants' model, the disengagement can be made as freely and with as little power as on Sickels' arrangement?

A. The friction on the defendants' apparatus is increased by reason of angles in the point of connection.

Q. Are there any such angles in Sickels'?

A. No, sir. 1564

Q. In view of that difference, supposing the governor to be applied to Sickels' by means of a slide, which would most impede the governor—the defendants' or Sickels'?

A. At that point, it would be decidedly in favor of Sickels'. The difference of friction in these two cases are so trifling that they would hardly be perceptible.

On being *cross-examined*, the witness, Daniel Barnum, testified as follows:

Q. Did you have an interest in this patent of 1842? 1565

A. I had.

Q. What interest, and when?

A. In 1845, I think it was, I was so unfortunate as to have some funds in the hands of Rodman & Co. when they failed, and Mr. Rodman assigned to me an interest in the patent, as security for that money.

Q. How long did you hold it?

A. Three or four years. I cannot now tell exactly the time. I believe five or six years. I did very little with it at the time.

Q. Do you know whether it was the same Rodman that was defendant in the other suit that has been spoken of on this trial?

A. I have no particular knowledge with regard to that suit.

Q. Was it John F. Rodman?

A. It was.

Barnum

1566 On being *re-examined*, the witness, Daniel Barnum, testified as follows:

Q. Have you had any interest whatever in this patent since you parted with it?

A. None at all, sir.

Q. Do you know when Rodman acquired his interest in that patent?

A. I do not.

Mr. Seward.—How long have you lived in New York?

A. I moved to New York, in the first instance, in 1845. I lived here until 1850, I think, and then I went to Phila-
1567 delphia, and lived there two years; and then I came back here again.

Q. Where were you from when you came here?

A. From Connecticut.

Mr. Keller.—Do you know if Rodman's interest was acquired before or after the 7th day of December, 1842?

A. I think it must have been after that time. I think it was after I came here.

Q. When did you come here?

A. I came here in 1845. I think he had no interest when I came here. I was connected with them more or less, and
1568 I think it was after that.

The evidence on both sides was here closed, and the Court adjourned to January 11th, 1855, at 11 o'clock, A. M.

January 11th, 1855, 11 o'clock, A. M.

The plaintiffs prayed the Court to instruct the jury as follows:

First Issue.

1. The patent laws require that the patentee shall give a full, clear and exact description of the manner of making, constructing and using the invention claimed and patented,
1569 so that any one skilled in the art most nearly connected, may make, construct and use the same; and the object of this provision of the law is, that at the expiration of the term of the patent, the public may have the benefit of the invention. This provision of the statute does not, however, limit the rights of the patentee to the special form of construction so described by the patentee; but extends his right of property over every modification of form which
1570 embodies the same invention, or any improvement thereof which is either an addition to, or merely a modification of, and involves within its boundaries, the original and patented invention.

2. If the jury find in the defendants' engine, substantially, either the construction, the arrangement or the combina-

tion described in Sickels' patent, for tripping and closing 1571
the valves of steam-engines, to apply steam expansively, they must find the first issue in favor of the plaintiffs, notwithstanding they may also find that the said construction, arrangement or combination has been modified in form, or has been improved, so as to produce effects or results in addition to, or beyond the results or effects produced by the invention described in Sickels' patent.

3. In a patent for a combination, such patent covers not
only the combination of all mechanical equivalents which 1572
may be substituted for the elements of the combination invented, but all mechanical devices which, in the combination, perform the same mechanical functions or offices, notwithstanding they may perform, in addition, other functions or offices, or perform the same functions or offices in a superior or inferior degree.

4. Letters Patent for a mechanical combination, secure to
the patentee the mode of operation resulting from the new 1573
combination, however the result or effect may be modified in degree by the substitution of either inferior or superior mechanical equivalents.

5. It is not sufficient, for the purpose of destroying the substantial identity of the defendants' apparatus with that of the plaintiffs', that there is such difference between the two as to indicate that thought, skill or invention was required to pass from the one to the other; provided the defendants' construction, arrangement or combination involves within its boundaries either the construction, arrange-
ment or combination of the patented invention, and the 1574
thought, skill or invention found in the defendants' is either in additions to, or improvements of, the patentee's invention.

6. On the question of the substantial identity of the defendants' apparatus with the plaintiffs', it is immaterial how far superior or inferior the one may be to the other, so long as the defendants' apparatus includes the plaintiffs' combination of elements, or any mechanical equivalents thereof.

7. The first part of the said Sickels' invention, is for a
combination of, *first*, the valve-stem, or any equivalent 1575
thereof; *second*, a spring-catch, or any equivalent thereof; and *third*, the adjustable piece, or its equivalent, and the appendages of these elements necessary to the co-operation of these elements to effect the cutting off of the steam in steam-engines, which combination results in a mode of operation by which the valve is alternately connected with and disconnected from the mechanism deriving motion from the engine, so that it may be opened, and the connection be broken at any desired part of the stroke of theengine,

1576 that the valve may be closed by the force of gravity,
whilst the mechanism or valve-gear continues its motion,
and returns to re-engage the valve for a repetition of the
operation.

8. The standard and set screw described for holding and
securing the adjustable piece or stop, are mere appendages
of the combination, and the substitution of other means for
holding and securing the adjustable piece where it may be
1577 required does not destroy the substantial identity of the
plaintiffs' combination.

Second Issue.

9. The second part of the invention described in Sickels' patent, is for the purpose of regulating the closing of the valves as well as to prevent them from slamming, and if the defendants effect either or both of these purposes or results by an apparatus substantially like the plaintiffs', then the second issue must be found for the plaintiffs.

1578 10. If the defendants' air-dash-pot and weight, and the
plaintiffs' water-dash-pot and plunger have substantially
the same mode of operation, the second issue must be found
for the plaintiffs.

11. If the effects or results produced by the defendants'
air-dash-pot and weight only differ in degree from the
effects or results produced by the plaintiffs' dash-pot and
plunger, such difference in degree will not justify the jury
in finding the second issue in favor of the defendants, so
1579 long as the means employed are substantially alike.

12. If the jury are satisfied that air is a fluid, and is employed by the defendants in connection with means which are substantially identical with the means described in Sickels' patent, for the purpose of regulating the closing of the valves, the mere substitution of air for water or other fluid does not destroy the substantial identity of the second part of Sickels' invention.

13. The substitution of mere equivalents for the means
1580 described under the second part of Sickels' invention,
although producing results differing in degree, does not de-
stroy the substantial identity of Sickels' invention.

14. If the jury are satisfied that the means employed by the defendants prevent the slamming of the weight, and such means are substantially identical with the means described by Sickels to prevent the slamming of the valves, and the use of such means prevents injurious consequences which otherwise would result to the engine from the rapid closing of the valves by the force of gravity, they must find the second issue for the plaintiffs.

The defendants prayed the court to instruct the jury as 1581
follows:

First Issue.

1. The patent laws require the patentee to teach, by his specification, a mechanic skilled in the art, to construct the thing described and claimed in his patent, and, if a mechanic could not construct the arrangement or combination of apparatus used by the defendants for the more readily cutting off steam in working the steam engine, from the description in Sickels' specification of the construction, arrangement, or combination of the apparatus described in
and claimed by Sickels' specification for the more readily 1582
cutting off steam in working the steam engine, without going beyond such description and tasking his invention, or without substituting, in place of the directions in Sickels' specifications, the results of his own thought and skill and ingenuity, then the constructions, arrangements, or combinations of the two apparatus are not substantially identical.

2. If, to pass from the construction, arrangement, or combination of Sickels' said apparatus to those of said ap-
paratus used by the defendants, would require thought, in- 1583
genuity, and skill, and the exercise of inventive power, and if the differences between the said two apparatus are not merely colorable, but are attended with important practical effects, and are necessary to secure those effects, then the constructions, arrangements, and combinations of the two apparatus are not substantially identical.

3. If the differences in the form, construction and ar-
rangement of the parts composing the said two apparatus, 1584
together with the effects and consequences of such differences, are considerable, in contradistinction to being merely colorable and trivial, then the constructions, arrangements, and combinations of the two apparatus are not substantially identical.

4. The said apparatus of Sickels is a combination of particular parts, namely, the valve-stem, the spring on the lifter, the adjustable sliding-piece, with its wedges or inclined planes, and their immediate appendages, namely, the
standard and setting screw, arranged in the manner de- 1585
scribed in Sickels' specification, and, in order to find that the said apparatus of Sickels, and the said apparatus used by the defendants, are substantially identical, the jury must find, in the said apparatus of the defendants, each one of said parts, or a mechanical equivalent therefor, and they must find such parts arranged and operating, in the said apparatus of the defendants, substantially in the same way in which

1586 the said parts are described in Sickels' specification as being arranged and as operating in his said apparatus.

5. If, in the said apparatus of the defendants, valve-gearing is used, whereby the valve-stem, or the lifter, or the spring on the lifter, or the adjustable sliding-piece, or its wedges or inclined planes, or the standard, or the setting screw, are either of them dispensed with, and if what is used by the defendants in the place of either of them is not a mere mechanical equivalent therefor, but is a different de-
1587 vice, having different powers and functions, then the said two apparatus are not substantially identical.

Second Issue.

6. The patent laws require the patentee to teach, by his specification, a mechanic skilled in the art, to construct the thing described and claimed in his patent, and, if a mechanic could not construct the arrangement of the apparatus used by the defendants for checking the descent of the weight in their air-cylinder, from the description, in Sickels' specifica-
1588 tion, of the construction or arrangement of the apparatus described in and claimed by Sickels' specification for regulating the closing of the valves and effectually preventing them from slamming, without going beyond such description, and tasking his invention, or without substituting, in place of the directions in Sickels' specification, the results of his own thought and skill and ingenuity, then the construction and arrangement of the two apparatus are not substantially identical.

1589 7. If, to pass from the construction and arrangement of Sickels' said apparatus to those of said apparatus used by the defendants, would require thought, ingenuity and skill, and the exercise of inventive power, and if the differences between the said two apparatus are not merely colorable, but are attended with important practical effects, and are necessary to secure those effects, then the constructions and arrangements of the two apparatus are not substantially identical.

1590 8. If the differences in the form, construction and arrangement of the parts composing the said two apparatus, together with the effects and consequences of such differences, are considerable, in contradistinction to being merely colorable and trivial, then the constructions and arrangements of the two apparatus are not substantially identical.

9. The said apparatus of Sickels is a water-reservoir, furnished with a piston or plunger attached at the lower end of the valve-stem, and operating within an adjustable cup or secondary reservoir, the whole arranged in the manner

described in Sickels' specification, and, in order to find 1591
that the said apparatus of Sickels, and the said apparatus used by the defendants, are substantially identical, the jury must find that the said apparatus of the defendants is constructed and arranged and operates substantially in the same way in which the said apparatus of Sickels is described in his specification as being arranged and as operating.

10. If the defendants, in their said apparatus, dispense with any part of the said apparatus of Sickels, and if
what is used by them in the place of any such part is not 1592
a mere mechanical equivalent therefor, but is a different device, having different powers and functions, then the said two apparatus are not substantially identical.

11. If the water reservoir, and piston or plunger, and adjustable cup or secondary reservoir, in the said apparatus of Sickels, are used for different purposes from the air-cylinder and weight in the defendants' apparatus, and produce a different effect, then the said two apparatus are not substantially identical.

12. The said apparatus of Sickels is described and 1593
claimed by him as intended to regulate the closing of the valves and effectually prevent them from slamming; and, if the defendants do not use an apparatus constructed and operating substantially like said apparatus of Sickels, or if they use their apparatus for a different end, then the said two apparatus are not substantially identical.

As to the effect of Corliss' Patents.

13. If the apparatus used by the defendants for the more readily cutting off steam, is covered by any claim in any
patent granted to George H. Corliss, then, in order that 1594
the jury shall be warranted in finding that the said apparatus, so used by the defendants is substantially identical with the apparatus described and claimed in Sickels' patent for the more readily cutting off steam, they must be satisfied, by countervailing evidence on the part of the plaintiffs, that such apparatus of Sickels and such apparatus of the defendants are substantially identical; because, the granting of such patent to Mr. Corliss, with such a claim, is *prima facie* evidence that any apparatus described and
claimed in such patent to Mr. Corliss is not substantially 1595
identical with any apparatus previously patented to Mr. Sickels, and such *prima facie* evidence must be overthrown by preponderant evidence on the part of the plaintiffs, in order to warrant the jury in finding in the affirmative on any issue submitted to them.

The case was then summed up to the jury on the part of the defendants by *Mr. Seward*, and the Court then adjourned to January 12th, 1855, at 11 o'clock A. M.

Charge

1596 January 12th, 1855, 11 o'clock A. M.

The case was summed up to the jury, on the part of the plaintiffs, by *Mr. Keller*, and the Court then adjourned to January 13th, 1855, at 11 o'clock A. M.

January 13th, 1855, 11 o'clock, A. M.

The Court (Judge Betts) charged the jury as follows:

Gentlemen of the Jury : The Court, in this case, has but a slender task to perform. You may, perhaps, be surprised at this statement. Nearly four weeks of your time have been
1597 devoted to the hearing of this cause. A mass of testimony has been produced and reduced to writing, which would occupy many days in being read over ; and points of law, of moment and intricacy, have been, in no small number, raised and ably discussed ; and the attention of the court and of the jury has been occupied with investigations into the science of mechanics and the state of the arts, each involving considerations of no slight interest and difficulty. It may, then, seem singular to you that, at the close of such a
1598 hearing, the Court should announce that very little devolves upon it to adjudge or determine in laying the case before you for your verdict upon it. It is so, however. The part that I am to act here is but an auxiliary one, and subordinate in its nature. This arises from the manner in which the case comes to a hearing in this Court. It is not an action at law, but a proceeding out of, and in assistance of, a suit pending in equity. A bill was filed on the equity side of
1599 this Court by the plaintiffs, praying an injunction to prohibit the defendants from operating Corliss' machine, and also seeking that redress which a Court of Chancery can give in damages. Before that Court, then, were placed all the merits of the controversy. The plaintiffs' right to seek a remedy, the defendants' means of avoiding that right, the questions of law, and the questions of fact, were all brought within the cognizance of the Equity Court ; and that Court, whatever may be the result of the proceedings upon this hearing, has ultimately to determine the whole
1600 merits of the case. To that Court it therefore belongs to inquire and ascertain whether the plaintiffs have a valid patent right, that is, whether Mr. Sickels was the original and first inventor of this alleged discovery ; whether there is novelty in it ; whether it is useful ; and whether it is a discovery for two classes of machinery, performing distinct offices, and each carrying within itself a perfect title, or whether the patentee claims a combination or union of two classes of machinery into one, rendering the patent entire for the joint co-òperation of the two, and not an independent inven-

tion and discovery of each one acting separate and apart 1601
from the other. Before that Court, also, will have to be inquired whether the defendants' machine infringes Sickels' discovery. That is a compound question, very intricate in its nature, and depending upon a variety of facts and principles of law. At first view, the defendants' machine may seem to act essentially in the same way as the plaintiffs'. It may present to the eye, substantially, the parts of the plaintiffs' machine, or the opposite of it; and it may, perhaps, use, to a great degree, the elements composing the plaintiffs' dis-
covery. Yet it is a principle of law, that if a patent is ta- 1602
ken out for a combination of apparatus, and another party interferes and possesses himself of a part of that combination, and uses only a part, such act does not amount to an infringement or violation of the patent—of the combination itself. That will be a question to be determined in the Court of Equity. It will also be a question to be determined in that Court, whether the defendants, under the two patents issued to Corliss, acquired any title; and, if so, what
that title covered, and whether it interferes with the patent 1603
of the plaintiffs. To that Court it belongs to inquire and determine whether the machine operated by the defendants was constructed in conformity to the paper grant to Corliss; and whether, upon the facts and evidence in the case, as it is operated, it conflicts with and violates the rights of the plaintiffs. These are questions yet, for aught we know, pending in that Court, to be decided. These are questions concomitant with all patent suits, and especially so with the questions of identity that have been raised and presented to us for investigation and decision. But, in this instance,
our duties are limited simply to the question of the sub- 1604
stantial identity of the two machines. It will, doubtless, occur to you that it would have been desirable that the entire action, with its complicated questions of law and of fact, so running together or springing out of it, should have been acted upon by one tribunal; and that the forum, whichever it might be, should have before it the determination of the entire question of merits, should settle the title of the plaintiffs, should determine the rights of the defendants, and
should therefrom deduce the conclusion whether the defend- 1605
ants were infringers, or whether the plaintiffs had no title.

I think it must be obvious to you, not only that there would be great propriety in keeping together these questions before one Court, from the nature and character of the subjects, but that, in other respects, there would be a surpassing importance in having the entire examination in the presence of one tribunal.

The Court of Equity, gentlemen, ordinarily proceeds upon evidence given by written depositions. They are

1606 taken out of the presence of the Court, and very frequently
in presence only of the party who procures them and offers
them on the hearing. There is not necessarily a cross-
examination of the witnesses, and, even if one is had, it can-
not always be relied upon as thorough and perfect. The
testimony may be taken before an officer who probably has
not the means of controlling the conduct of the witness
and of drawing from him his knowledge of matters on
inquiry so perfectly as might be desired and would be
effected in a court of justice. Accordingly, these deposi-
1607 tions are not unfrequently burthened and laden down with
irrelevant and rambling statements, and the attention of
the Court is greatly distracted and fatigued in sifting the
papers and in separating the unimportant from that which is
pertinent and valuable. It is difficult, oftentimes, to deter-
mine the proper effect to be given to statements thrown in
merely collaterally, and it is more difficult to ascertain
whether a witness is testifying to matters of fact within his
own knowledge or to conclusions of his judgment drawn
1608 from his experience or prejudices. As has been said by the
learned judge whose opinion in part was read yesterday to
you,—" these witnesses on affidavit all stand six feet high."
This metaphor is true and significant, and imports that the
Court or jury, when called upon to determine facts from
written depositions, have no means of distinguishing be-
tween the effect and value of one man's testimony and those
of another's. The witness who should measure relatively
five feet eight with his taller compeers in a deposition,
stands head and shoulders equal with the most experienced
1609 and competent of them. Before a jury, and in the presence
of a Court, there is the eminent advantage, not only to
become conscious that the witness is entitled to credit from
his character and acquirements, but to discriminate whether
he speaks from personal knowledge and familiarity with the
facts or whether he testifies upon opinion or hypothesis;
and you are satisfied, I have no doubt, from your experi-
ence in this case, of the importance of this test in determining
the weight which should be given to testimony, out of and
above the form of words in which it may be delivered.
You have heard the testimony of six or more experts upon
1610 the points in dispute between these parties. I think I may
anticipate your judgment that these witnesses are individu-
ally entitled to the fullest confidence in respect to integrity,
intelligence, experience and high attainments in many
branches of the arts and sciences; and yet it must be mani-
fest that, in regard to mechanical facts to the craft, and to the
specific subjects which have been investigated before you,
there are distinctions very important to be known in the
capability of these witnesses to give you instructions which

may safely be relied upon as guides to your judgment. 1611
The Court of Equity is deprived of the advantage you have
enjoyed, and I think it would be an important improve-
ment in the trial of patent causes, if, in all instances, the wit-
nesses were called in presence of the Court and there
examined. There would be a further advantage in that, not
to be overlooked. You have sat a period of twenty-five
days successively hearing this testimony. It has been taken
in your presence by stenographers, as delivered, and without
the pause of a moment to enable them to keep pace with
the utterance of the witness, and it is now before you, writ- 1612
ten out with a fullness and accuracy perfectly marvellous.
It is prepared now to repeat to you questions and answers
in the very words, emphasis and pauses employed by the
counsel and witnesses. The words seem to have been tran-
scribed on paper in almost their sounds as they fell from the
witnesses. Yet, if you had not seen these witnesses—if no
more than the words had been read over in your hearing,
could they have communicated to your minds the impression
springing now from their perusal, which, in effect, is a reitera-
tion *viva voce* by the witness of his statements, and thus re-
calls to your recollection, not his langnage only, but his 1613
tones, his looks, and his manner?

Moreover, a Court of Equity would enjoy a further ad-
vantage over you if it could hear evidence in the same
manner. You will now, at the termination of the trial,
after the remarks that I may submit to you, retire to con-
sider and decide the cause. What are you to do? Here is
testimony that has occupied three weeks in its delivery.
This evidence has not been discussed in any detail before
you. Its extent rendered that impracticable. It has scarcely
been adverted to by the counsel. They have, on the one side 1614
or the other, touched particular points bearing upon the great
features of their case, but have not read over the evidence
to you, nor restated it. They have not commented on its
credibility, weight or bearing in its various ramifications,
and thus afforded you the aid of their study and criticism of
its diversified qualities and effect. It will be impracticable
to take these quires of testimony into your room, and read
it, and compare its parts, and in that way master its full
force. How much time must it occupy? You have an il- 1615
lustration in point to that inquiry. One of your fellow-
jurors was absent two days from the panel, and, upon his
return, the testimony taken during that time was read to
him, and, to my surprise, it developed this great fact in the
management of jury trials—that testimony can be taken
orally from a witness, can be written down *verbatim* in
Court, he can be examined, and re-examined, and verify the
justness of the report of his evidence, within the time it re-

1616 quires to read over his statements after being written out. If you, then, had the time, as the Court of Equity would have, to take this statement on your retirement, and spend, not to-day and Monday, but weeks, if necessary, to a period as long as we have sat here, more than twenty days, in hearing this case, and then leisurely and considerately trace out upon these machines, by the light of that evidence, every feature in question, and carry in your minds, in the investigation, the impressions which the deportment, the character and the intelligence of the respective witnesses made upon you, would you not arrive at a determination more satisfactory, as to the substantial identity of the two machines,
1617 than you can do now?

The Court, without probably your sagacity and skill in mechanical arts, yet, by careful study, with the aid of books to interpret obscure phrases and terms, might possess itself of the technology of the arts, and learn the general principles of mechanical construction and science, sufficiently to appreciate and apply the testimony according to its sound effect, in deciding the points in controversy. It could do so with a deliberation not in your power to bestow, and, having had the witnesses in its presence and heard their testimony orally, and also having that testimony again brought before it so vividly as to seem
1618 to reproduce each witness to repeat it over and over in the very language in which it was delivered, the Court might, with the aid of the machinery, models, drawings, and descriptions of each particular part and arrangement of apparatus in either machine, proceed to analyze, compare, collate and determine the disputed facts, with vastly greater means and opportunity of doing justice between these parties than you possess or could employ, and it would, besides, have before it the merits of the case in all its bearings. That is not so at present. You, observe, gentlemen, that we take but a partial and imperfect cognizance of the cause. It is submitted to us in precise terms, but reserv-
1619 edly, and no further than the issues sent here to be tried indicate. We must examine it and render our decision upon it in conformity to the evidence applicable to those precise issues, and without regard to general merits. The Court of Equity, when it came to look into the case, (and how far that Court proceeded to adjudge upon it is not indicated to us,) heard, it appears, evidence and the arguments of counsel, and no doubt clearly apprehended the controlling features of the case, and wherein it might be serviceable to have further light upon it than was furnished by the proceedings in that Court. It paused in its determination and sent one portion of the case here for trial, or, what is equivalent, transferred it to another branch of

the same Court, to obtain the judgment of a jury upon two 1620
distinct and specific inquiries. Those inquiries, gentlemen,
are the guide and limit to the investigation that we are
called to make. The Court has specified, in its inquiries, the
exact difficulty in the way of the disposition of the cause in
Equity. When that difficulty shall be obviated by your
verdict, that Court will be prepared to proceed and make a
final determination of the whole subject. The awkward-
ness of these proceedings, as illustrative of the importance
of having the entire case within the control of one Court,
will be observable in this, that after all this toil of yours, 1621
after this prolonged controversy, and after your verdict
shall have been sent to the Court of Equity, it is the right
of the party against whom your finding may be, to move
that Court to disregard it wholly. It is the right of that
Court to decide the cause irrespective of the verdict; and it
is the right of both parties to bring before the Court of
Equity, on final hearing, the testimony taken on this trial,
and use it there as proof upon written depositions, the
Judge in Equity not having any benefit of this personal
examination of the witnesses, unless indeed it should 1622
chance, from the peculiar organization of this Court, that
the Judge who now presides here should be the one, or
one of the two, who may sit at the final hearing of the cause
in Equity. That contingency is not contemplated in the
order, nor is it likely to occur. If it comes to the Judge
from whom these issues proceeded, he will be put to the
responsibility of determining the facts passed upon by you,
on a rehearsal only of evidence stated upon paper, without
that most vivid and impressive commentary which the pre-
sence, action, delivery, and manner of the witnesses are 1623
calculated to give it.

What then are the questions we have to deal with? They
are stated in these issues, and it will be important that you
should pay attention to the phraseology and emphasis of
these directions, because I do not contemplate, myself, to
speak at any great length upon any branch of this case.

"Ordered: That the following questions be tried at law,
"before a jury, in the first above-named cause, at the next
"regular term of this Court to be held in the Southern Dis- 1624
"trict of New York, namely:

"I. Whether or not the construction, arrangement or
"combination of the apparatus used by the defendants for
"the more readily cutting off steam in working the steam-
"engine, as charged by the complainants in their bill, are
"substantially identical with the construction, arrangement
"or combination of the apparatus described in and claimed
"by the complainants under the patent granted to F. E.

1625 "Sickels, 20th May, 1842, for the more readily cutting off "steam in working the steam-engine."

In the first place, there is presented to your attention a hypothetical inquiry. You are to make a comparison, and draw a conclusion from that comparison. One set of apparatus is to be compared with another, and you are to determine, in that way, whether the defendants' is substantially identical with the plaintiffs', without any definition given you, by the terms of the issues, of the nature and mode of operation of the plaintiffs' apparatus.
1626 What, then, are you to take as the foundation of this comparison? There must be some criterion established, to enable you to draw the comparison required at your hands. The criterion indicated by this order, is the construction, arrangement or combination of either part of the apparatus described in and claimed by the complainants under the patent granted to F. E. Sickels. Although this order does not, in terms, impose upon the Court the necessity of construing that patent, of determining its scope and fixing its limits, or of adjudging in what way it operates, yet, to a cer-
1627 tain extent, there may be a necessity for a legal exposition, on this trial, of some of its terms. You will take first, however, the fact, conceded throughout the trial—that the black model before you is a fair exhibit of the invention of the patentee—that that embodies to the eye all the combination of the parts, and a representation of the apparatus that is claimed under the Sickels patent. Yet, it is necessary to know, to a certain extent, what is its principle; because, the vitality of this apparatus or combination lies beyond the mere parts of machinery, or mechanical instruments pre-
1628 sented by it. The apparatus is put together for some object. It is calculated to effect some end; and, as the order of the Court of Equity does not determine what its purpose is, this Court is to ascertain and declare that, from the description and claim given by the specification, and set up on the part of the plaintiffs in their bill. Substantially, in my opinion, the spirit or purpose of the first part of this contrivance is, a means or process by which, in operating the valve-stem which carries in its ascent and descent the valves, the steam may be cut off at a fixed point of the pro-
1629 gress of the piston previous to its running out the whole length of its stroke, so that the steam shall cease to be passed into the cylinder. It is not questioned, but that long anterior to this patent, that fact, as an essential particular in the management of steam-engines, was familiar to engineers, and that, in practice, steam was cut off at half-stroke when atmospheric engines were in operation; and this must necessarily be so, otherwise, the engine or piston is left to the unmanaged control of the power propelling it.

That was done by a very different apparatus from this. 1630
And it may be assumed in this case, so far as the question before you is concerned, that the patentee has a legal title to his device, and to his means for effecting that object. The principle, then, of his invention is, a process or means by which the engine, whilst in operation, is enabled, after lifting a steam-valve off its seat, to trip the valve, as it is termed—that is, cause it to be detached, and the steam-valve to be carried back to its place by its own gravity. That idea, no doubt, is patentable; but, still, it is obvious that a
machine in action, with that improvement only, would be 1631
exposed to injury by the slamming or concussion of the valves as they dropped to their seats, as it appears that these valves are heavy metallic plates or wedges, or whatever form they may have, and fall with considerable force. The contrivance referred to in the first issue has relation to the branch of the discovery which concerns the tripping, and the principle of it is, that that apparatus must be so arranged and constructed as to take hold of the valve-stem by means of a spring entering into notches on the stem, by
which the stem is carried up by the lifter to a particular 1632
point, where a wedge is stationed on an upright, and so formed upon its faces or edges that the points of the spring which clasps the body of the stem will pass over the exterior sides of the wedge, and by it be pressed apart, so as to let loose the valve-stem, and leave the valve free to fall by its weight; and then, the engine, passing down to its first position, will re-seize or take up the stem and carry it up to perform again the same operation, without the interposition of any manual assistance. This, no doubt, was
regarded by the Court of Equity as a patentable discovery, 1633
and to have been well secured, by this patent, to Mr. Sickels, as the order reasonably imports; but, if the decision of that point by the Court of Equity is not to be implied, then you are to take it as the instruction of this Court.

Again, as to the second issue—for it will be more convenient to state the case to you as an entirety, than to separate it into parts, because it is substantially one question under two heads—that inquiry is: "Whether or not the construction and arrangement" (dropping the word combina-
"tion in this) "of the apparatus for preventing the slamming 1634
"of the valves in closing, used by the defendants, as "charged in the bill, are substantially identical with the "construction and arrangement of the apparatus described "in and claimed by the complainants under the aforesaid "patent."

There are two particulars prominent upon this inquiry: In the first place, that the Court of Equity does not understand, or did not regard it as a point to be embraced in

1635 this issue, that there is any claim, in the patent, for a combination of apparatus to effect that object; and the other fact—a very important one, certainly, in regard to this controversy—that the Court did understand and does impliedly assert in this order of issue, that the defendants were using a machine or contrivance to prevent the slamming of their valves, and not leaving it an open question of inquiry whether the air-pots placed under the machine of the defendants are there for a purpose wholly diverse and
1636 different from that intended by the plaintiffs' dash-pot and plunger (a view most ably pressed by the argument for the defendants)—on the contrary, that that Court did consider the contrivance to be applied by the defendants for the purpose of preventing the valves from slamming, and, therefore, to be used in like manner and to the same end as that described in the claim of the plaintiffs is used by them. The Judge, in framing the order, in effect disposes of that point. He plainly acts upon the assumption that the charge in the bill was established before him—that
1637 these air-cylinders were used, in closing the valves, in order to prevent the slamming—and he seeks information from you, not whether that be the effect and purpose of the apparatus and contrivance, but whether, having that effect and purpose, it be substantially identical with the contrivance of the plaintiffs, in the use of their water-dash-pots. The contrivance of the plaintiffs is a pot of wood or metal, probably metal in practice, forming a sort of cylinder or cistern, prepared for holding water, or, as the patent says, "other fluid." The cylinder is of equal size to a certain
1638 point, and then a subordinate or inferior chamber is made in the body of the cylinder, or a movable one placed below or within it. This chamber terminates in a contraction, diminishing in circumference from its commencement in the cylinder. Above this cup, or secondary chamber, there is sufficient space between the plunger and the cylinder for the escape of the water. The cylinder, or dash-pot, is placed in water or filled with water, also surrounding it. The dasher, piston or plunger, is prepared of a size to move easily within the circumference of the main cylinder or pot until it approaches the smaller cup or chamber, driving the
1639 water under it, and, having passed into the secondary cup, all the water not pressed out concentrates in the cup or secondary chamber. Thus, the water, yielding gradually to the pressure of the plunger, checks its descent, and stops it without jar or concussion, as it closes the aperture at the instant the valve settles upon its seat. The cup or secondary chamber is made adjustable by a screw or other device, so as to stop the plunger at such a point of its descent as shall precisely correspond to the touching or seating

of the valve upon its bed. Consequently, when this 1640
machine is in operation and the valve is let drop, instead
of allowing the valve to rush to its seat by the force of
gravity or its own weight, the plunger and water-pot, so
constructed and arranged, allow it to sink rapidly until it
gets to the point of closing, when it is checked and the
valve is closed without slamming or any jar upon any por-
tions of the machine. That is the principle. It is not de-
nied that in construction and operation this principle is
carried out, and that the patentee has succeeded in effectu-
ating what he proposed. It is urged, with great power of
argument, upon the evidence of Mr. Hogg, that Sickels is 1641
not the inventor of his plan, but borrowed it from a previous
discovery of Mr. Hogg. You are, however, to bear in mind
that the validity of this patent is not on trial here. That
question belongs to the Court of Equity. The testimony
was admitted here to a different end, which was explained
at the time—that is, to show the dissimilarity of the plain-
tiffs' dash-pot, in its arrangement and construction, to that
of the defendants, and to that end alone it is entitled to be
considered by you. After you get before your minds the
principle of the plaintiffs' machine, the point of inquiry
will be solely whether the defendants are using an arrange- 1642
ment or construction of apparatus, which, in the terms of
the issue, is substantially identical with that claimed by the
plaintiffs for preventing the slamming of the valves. A
question of law is raised whether the patentee is not restrict-
ed, by his claim, to the use of water alone in his dash-pot,
so that the use of any other agency, fluid or not, for the
same purpose, is free to anybody who may devise a means
of employing it. That question will not be before you, but
will be hereafter disposed of as a point of law. You have,
then, before you the principle of the plaintiffs' apparatus. 1643
The policy of the patent law is, to secure to discoverers and
inventors a property in their inventions, and to give them a
perfect right to enjoy it to the exclusion of all others. That
is the benign scope and aim of the law; but it recognizes
and proceeds upon another policy, equally important and
prevailing—that persons, under the form of a patent, cannot
be permitted to possess themselves of things known to the
public. A further principle applicable to this case, and no
less important, is, that one man, by entering the field of dis-
covery, and projecting and perfecting useful inventions, does
not thereby exclude others. Everybody else may pursue 1644
the same object in the same department of discovery. That
Mr. Sickels has invented these two machines and brought
them to practical and beneficial use, does not prevent Mr.
Corliss from accomplishing the same purposes by inventions
of his own, provided he invents some new instrumentality

1645 or creates some new combination distinct from that employed by Mr. Sickels. The plaintiffs acquire, under the patent, nothing more than the specific invention of Mr. Sickels; and that cannot be the general idea or principle of cutting off steam by detaching a valve-stem from a lifter, or so bringing it back with the valve as to reseat it without slamming. The invention securable under the patent, is the construction, arrangement or combination of apparatus in a new way to effect that purpose and result. Every other person may do the same thing by a method or pro-
1646 cess substantially different from that patented to Sickels. So, also, every one has a right to patent an improvement upon that machine, and Mr. Sickels could not use the improvement without the license of the inventor and patentee of it. The law lays the same restriction on him, and he cannot apply his improvement to Mr. Sickels' patent and use that without the consent of the plaintiffs. It is of no importance on this issue if the defendants have made important improvements on the plaintiffs' machine, enhancing its value and efficiency—the rights of the parties in the present inquiry depending upon the fact whether, in the construction
1647 of their machine, the defendants have got into it substantially what was Sickels' discovery. Mr. Corliss may have superadded particulars transcending in value the original discovery; but that circumstance in no way authorizes him to appropriate the invention and discovery of the patentee. Mr. Corliss took out two patents subsequently to the issue of the patent to Sickels, and those patents are *prima facie* evidence that the defendants' machine, if made conformably to them, does not interfere with Mr. Sickels'. The patent law confers upon the Commissioner of Patents authority to
1648 issue patents. He does not do it upon the mere application or petition of a person, representing that he has made a discovery, but it is done, as it were, judicially, after full examination and inquiry. He is aided by officials schooled in the subject. The officers are created for the purpose of that investigation, and are supposed to make it with impartiality, skill and fidelity. It is their duty to become cognizant of the arts as they existed at the time; and in this case it is to be assumed that they had before them Sickels'
1649 patent, and understood its purport, and pronounced, in their judgment, that Corliss' patents would not interfere with it, and that, on such conclusion, patents were issued to him for his arrangements and improvements. This, in law, is *prima facie* evidence of good title in him, and that his machine does not interfere with Sickels' patent, and it then devolves upon the plaintiffs to produce sufficient proof to show, that notwithstanding the subsequent grant of those patents, they do, in fact, incorporate within the grant substantially the

discovery of Sickels; and, if that is proved satisfactorily to 1650
the jury, then they must find for the affirmative of the issues.

These preliminary observations are intended to direct your attention with distinctness to the sole questions you are to pass upon—whether or not the defendants' machine embraces and embodies within it a construction, arrangement or combination substantially identical with the tripping apparatus of Sickels, or substantially identical with the dash-pot employed by Mr. Sickels. The jury are not bound
to find the same verdict upon both issues. You can differ 1651
in your finding accordingly as the facts impress your judgment.

The Court will limit its remarks to the explanation of a few propositions of law bearing upon these issues. It is evident from the nature of the case, that various controvertible questions of law must be involved in it; and that it is so, is demonstrated by the fact that the learned counsel have submitted to the Court, for their respective parties, nearly thirty distinct prayers for instructions upon separate
propositions of law. Most of them, in my judgment, enter 1652
into the main merits of the case, and will more appropriately be addressed to the tribunal which will ultimately dispose of the cause. The principle involved in several of them is, no doubt, pertinent to the questions submitted to you, and I shall submit to you briefly my views upon them before I close my remarks.

We are driven somewhat to definitions of terms, as a guide in this case. The inquiry is, whether the machine or apparatus used by the defendants, is substantially identical
with that claimed by the plaintiffs. You have got your 1653
point of comparison. That is ascertained—the black model, which embodies what Mr. Sickels describes and claims—and you are next to ascertain whether or not what the defendants use is substantially identical with it. *Substantially identical* is a phrase, not denoting positive sameness, yet significant of more than resemblance and similarity between the things to be compared together or considered in conjunction. *Substantially* is thus used diminutively—reducing and not strengthening the force of *identical*. If the Court
of Equity had demanded of you whether the two machines 1654
were identical, the inquiry would be solved by a mere glance; because, by turning to one model and the other you would be prepared with a response without reasoning or hesitation, for, in order to be *identical*, the two must correspond in all respects—be taken indifferently one for the other. The difficulty, then, will be, in fixing what *substantially*, as so used, imports. A *substantial identity*, in this connection, I apprehend, implies that the defendants'

Substantially
identical

1655 construction and arrangement incorporates and employs the principles embraced in the plaintiffs' apparatus, without the introduction of any discovery or invention on their part, unless they are excused under the other suggestion that has already been made to you, that they do so by the employment of some machinery, some mechanical instruments, entirely different from those of the plaintiffs, novel to them, and not embraced in the plaintiffs' patent. It would be so in commonp arlance, and, in a legal and artistical sense and acceptation, the *substantial identity* of one piece of mechan-
1656 ism with another, may be taken to be that degree of sameness which demonstrates that both include one principle and invention, and are operated to a common purpose and result. Whether this be so in this instance is a matter of fact exclusively, for the decision of the jury upon the evidence; and, if it be so found by their verdict, it is not the province of this Court to draw therefrom the conclusion that it amounts to an infringement of the patent. That point still remains before the Court of Equity to be disposed of
1657 by that tribunal. It by no means follows that a patent right is violated by an unlicensed use of the principle of the invention, or of a portion of the contrivance or apparatus by which the patentee carries out his discovery; because, when that is done by means of a combination of machinery, and the party complained against uses a part only of such combination or contrivance, and not the whole of it, he is not chargeable as an infringer of the patent, upon a doctrine which it is not necessary to discuss here. The Court of Equity neither inquires of you nor of this Court,
1658 whether the construction and apparatus of the defendants, if it includes the whole or a part of the invention of the patentee, amounts to an infringement of the plaintiffs' right, nor whether the defendants have transferred into their contrivance the entire combination in the plaintiffs' apparatus. If the defendants are using the principle of Sickels' invention, and have got the main features of his machinery in theirs, although a part of the combination is dropped and the plaintiffs' contrivance is added to and improved by them, their machine would be substantially iden-
1659 tical with the plaintiffs'. As, for instance—suppose that an important and essential part of the patentee's combination, as here exhibited, be the use of the screw which holds his adjustable sliding piece to its place, and that the defendants had transferred his apparatus into theirs without the use of that screw, and made it work well with that omission, still, in law, so using the machine without the screw would not be a violation of the patent, although a jury might justifiably find the two machines to be substantially identical. Thus, there may be a substantial iden-

tity in the process of working, in the mechanical arrange- 1660
ments, means, adjustments and combinations which are employed in the two machines, by using less than the whole of the plaintiffs' contrivance described in the patent, and without violating it. Further, the defendants' machine, in contemplation of law, may be substantially identical with the plaintiffs', and be also an infringement of it, although applied to different uses, ends and purposes. The questions propounded in these issues are not, therefore, disposed of by
showing that the defendants' machine is better or worse 1661
than the plaintiffs'; that it is applied to the same or to different purposes; or that it may not infringe the plaintiffs' patent. The property remains the plaintiffs' so long as it retains that substantial identity, and cannot be divested or affected by means of any new use or improvement of it by the defendants, whatever the novelty, utility, or ingenuity of such new use may be. That doctrine is well exemplified by the history of stationary engines. The steam-engine was supposed incapable of being used for marine purposes, until Fulton's experiments. He applied it to navigation,
but was unable to secure that mode of use to himself. Ex- 1662
ceedingly important as was that new application, and so nearly of kin to the highest efforts of invention, yet it did not entitle him to appropriate it to himself by a patent. All that could have been patented to him in that respect would have been some peculiar method or means devised for adapting steam-engines to nautical propulsion, instead of operating as a stationary power. Nor would it become a criterion of substantial difference, that the defendants' machine is intended to answer purposes directly opposite
to any the plaintiffs proposed to perform by their's. The 1663
principle deducible from this is, that admitting that the air-cylinder of the defendants' machine was not constructed to prevent a slamming of valves, and it should appear that there can be no slamming of rotating valves as used in it, and that it is used and was designed to hold back the valves after they had passed the point where a slamming could occur, still, if the defendants employ the parts and construction, the arrangement and combination of the plaintiffs' machine, with its capacity and functions, it is unimportant to what results or objects it is applied, except it
may be so in a point of view to be hereafter considered, 1664
i. e., to help to ascertain the principles entering into and characterizing the construction itself.

In order to constitute a substantial identity of mechanical structure, it is not necessary that all the parts used in creating or working it should be exactly the same. All the experts examined in the cause agree that this is so in the arts, and the law puts no different meaning upon the terms.

1665 With artizans in work-shops, various devices and instru-
ments, well known to the arts, may be used to a common
effect. Take, in illustration, the adjustable slide exhibited
in the plaintiffs' model. It is there held by a screw.
According to the testimony of the experts, it might as well
be held by a spring or pulley or weight. The principle is,
that neither in fact or law does the substantial identity of
one mechanism with another depend upon the similar or
dissimilar form of the instrumentality entering into their
composition. Different means or methods, capable of
1666 working to a common end, may be interchanged and sub-
stituted one for another according to the will of the artist,
and these are the common-place expedients at the command
of his skill and dexterity. These substitutes are known in
the arts as *mechanical equivalents*. Still, that term is
not one which has acquired a perspicuous and precise
meaning in law. The proofs do not show that there is any
definitive and established signification of the term in
mechanics, and you are left to gather from the evidence
1667 what is ordinarily understood to be its import and applica-
tion practically in the arts and sciences. Having ascer-
tained this matter to your satisfaction, you will be prepared
to determine if the defendants have framed or created their
machine by instrumentalities, which, in a mechanical sense,
are equivalent to the parts employed in the combination of
the plaintiffs.

In entering upon the examination of the two structures to
determine that point, several considerations will be entitled
to weight as guides to your conclusions. First, the thought
1668 and intent disclosed in the machines. What are both used
for, each as an entirety, and do they effect a common ob-
ject and result? The controlling principle of the plaintiffs'
machine has been explained to you by the Court, in giving
a construction of the claim set up by them in this action,
and stated upon their bill. Is the same principle manifested
in the defendants' machine, and is it used for like purposes,
and operated by means and apparatus substantially identi-
cal with what are found in the plaintiffs'? You are to
solve these inquiries upon your own judgment and convic-
1669 tion, enlightened by the testimony of the experts and
machinists, who have explained before you, upon the models,
their views on these subjects. The burthen in your duty
lies in appreciating and applying that testimony. These
learned and experienced gentlemen differ widely in opinion
in respect to those points. You are to ascertain whether
or not it has been proven to your satisfaction, that the com-
bination and construction of the defendants' machinery
embodies the idea and principle of the plaintiffs' contriv-
ance, and carries it into effect by mechanical equivalents.

It is hardly necessary to repeat what has been suggested 1670
already, that you would not be able to determine this fact
by mere inspection of the apparatus, unless you are mechanicians schooled in that branch of the arts, and must, therefore, found your opinions essentially on information obtained on the trial, from experts and the books.

In examining the defendants' apparatus, and recalling to mind the evidence as to its capacity and functions, do you find that the purpose and operation of it is to trip the valves
and cut off steam at some points of the stroke of the piston, 1671
either at, beyond, or below half-stroke? If you find such to be its design and effect, then you will trace out the means by which that idea is carried into execution, and compare it with the plaintiffs' process and apparatus in their machine, whether acting perpendicularly or horizontally. When the machine is vertical, the valve is tripped by opening the spring which clasps the valve-stem, which being thus disengaged, the valve falls to its seat by its own weight. Does the defendants' machine exhibit a similar
contrivance for a like purpose? If you find the working of 1672
the two machines to be alike in this particular, you will seek by aid of the testimony, and decide, whether the construction, arrangement, and combination of means and apparatus for doing it by the defendants, is or not substantially the same as is employed by the plaintiffs. In such investigation, you will be required to ascertain whether the defendants' apparatus, in appearance seemingly so unlike the plaintiffs', is rendered substantially identical with it, by the use of mechanical equivalents for the plaintiffs' construction.

One piece of mechanism may be a mechanical equiva- 1673
lent for another, without similitude to it in parts or operation. Thus weights and the compressive action of springs may be equivalents of each other, or wheels, rock-shafts, joints, wedges, pullies, and levers, be made, in various conditions, equivalent powers, and be substituted interchangeably, in mechanical construc~~tions~~, for effectuating a common purpose.

equivalent

An artist has command of diversified means by which a given mechanism may be formed, or a particular mechanical power be exercised. One may accomplish an object by
very simple and direct methods; another may employ exceed- 1674
ingly complicated arrangements for the same purpose, and his method may prove the best. In this instance, the patent of the plaintiffs cannot be interfered with because the patentee may have selected an inferior class of mechanical means for executing his invention, and even though the defendants may have employed a better one. The law would deem that merely an election between known instrument-

Equivalents

1675 alities common to all mechanics. Accordingly, as previously stated, the substitution of one form or mode of construction or gearing, or shape or size of the parts by which the thing to be effected is carried out, when the same design is in view, would, in judgment of law, be but the use of mechanical equivalents, and render the structures substantially identical.

If you find, upon the proofs, that the combination of parts in the defendants' apparatus differs not colorably, but essentially, from the plaintiffs', and that invention has
1676 been employed in the arrangement, construction, or combination of any part of the defendants' apparatus alleged to be like the plaintiffs' invention, in such case, the defendants' machine is, in contemplation of law, substantially different from that of the plaintiffs'. Your decision will be the same, if you are satisfied, upon the evidence, that the defendants' machine could not be constructed from the specification in the plaintiffs' patent, or a view of his machine, by a machinist of competent skill, with the use only of instrumentalities known to mechanics, but would re-
1677 quire of him the employment of additional means. There would, in such case, come into it the new element of invention and discovery, which every party has a right to employ. If you find that the defendants, in this case, have incorporated so much of the plaintiffs' machine in theirs as to amount to a violation of the patent, it may not follow, as a legal sequence, that their machine is thus made substantially identical with the patentee's. They may have possessed themselves of his invention without license, and be subject to an action at law, or an injunction in Equity, for
1678 the wrong, and yet, by new inventions added to it, have created a machine or apparatus substantially different in structure and purpose from his.

I have thus suggested to you the questions of fact involved in this case, and submit it to your decision, without intending to intimate any opinion upon the facts. I should feel much embarrassed, with the slight information I possess on this branch of the arts, in coming to a decision upon them satisfactory to my own mind. If sitting in Equity, it would be my province to do it; but, by the aid of such
1679 investigations as have been had here, I should, in that forum, be clothed with advantages I cannot exercise now, and of which you also are deprived. I could have before me the drawings, models, recorded evidence and instructions of the books, to study, with my own command of time for acquiring a sound knowledge of the facts. The law presumes a jury to be more competent than the Court to determine matters of fact, and also that they can do it

promptly, without the hesitation and prolonged reflection 1680
with which facts are dealt with by Judges.

I am aware it will be quite impossible for the Jury to peruse the evidence they have heard in this case. Days, and probably weeks, would be requisite to enable them to do it satisfactorily; but I have no doubt your sagacity and business experience, aided by the exceedingly strict attention you have devoted to the evidence and the arguments, have qualified you to give to the Court of Equity the proper responses to the questions propounded to you.

I shall close these remarks by submitting instructions in 1681
regard to points of law prayed by both parties. Each party has a right, under our proceedings, to ask for instructions to the jury, upon points of law involved in the case, and to specify the points upon which instructions are asked. Such prayers were handed to me yesterday, embracing, upon one side, fourteen specifications of instructions asked for, and, on the other, thirteen. The instructions I shall lay before you are embraced in written propositions, which I
shall read. The particular instructions prayed by counsel 1682
are to be considered as refused by the Court, if not included in those now submitted to you. They are as follows:

"1. The Court is not called upon, on this trial, to determine the legal effect of the specification and claim, or the character and extent of the right acquired under Sickels' patent."

I do not intend to decide whether, under that patent, the two contrivances form one, and that the plaintiffs must show
that there has been a violation of the entire patent. That 1683
matter I do not adjudge. I only submit it to you to inquire into these separate discoveries of the patented rights, and you are to determine whether, in respect to either of them, the defendants' machine is substantially identical with the plaintiffs'.

"2. The issues sent here for trial assume that the patent embraces two independent inventions, and no question is made on the trial, but that the specification and claim plainly designate both inventions, and that they are cor-
rectly represented by the models exhibited in Court. 1684

3. Neither is there any dispute but that the model exhibited in Court by the defendants, correctly represents the machine used by them. They put in evidence two patents to Corliss, and, if the evidence proves that the machine of the defendants is constructed according to either or both of these patents, the machine is to be regarded, *prima facie*, as not embraced within the patent to Sickels, and the burthen is cast upon the plaintiffs to disprove its dissimilarity, and

1685 to prove that it is substantially identical with Sickels' machine."

I have made all the remarks that are necessary for your comprehension of that principle of law.

" 4. The plaintiffs are entitled to the exclusive use of the construction, arrangement or combination of apparatus, described and claimed under Sickels' patent; but the defendants are entitled to invent and use any new and different machinery or apparatus or combination, which may
1686 accomplish the like results with that of plaintiffs, but cannot employ mechanical equivalents to that end.

5. The term "mechanical equivalents," is not easily reduced to a perspicuous definite meaning. It, however, excludes the idea of invention. In general, it may be described as being the substitution of one mechanical power for another, or of one form, proportion or dimension of instruments for another, or a mode of gearing or arranging parts of a machine, so as to use the principles of the machine,
1687 under a different form and appearance.

6. The issues seek to have answers to two inquiries:

'*First*—Whether or not the construction, arrangement or combination of the apparatus used by the defendants for the more readily cutting off steam, in working the steam-engine, as charged by complainants in their bill, are substantially identical with the construction, arrangement or combination of the apparatus described in and claimed by the complainants under the patent granted to F. E. Sickels, 20th May, 1842, for the more readily cutting off steam in
1688 working the steam-engine; and

Second—Whether or not the construction and arrangement of the apparatus for preventing the slamming of the valves in closing, used by the defendants, as charged in the bill, are substantially identical with the construction and arrangement of the apparatus described in and claimed by the complainants under the aforesaid patent.'

7. The apparatus of the defendants will be substantially identical with that of the plaintiffs, within the provisions and meaning of the issues, if it embodies the same princi-
1689 ples and accomplishes the same purposes, objects and effects, however dissimilar in appearance or form the instrumentality and mechanism used by the defendants may be.

8. The machine of the defendants, in the case last supposed, will also be substantially identical with the plaintiffs', although it accomplishes other purposes not effected by the plaintiffs', and in a better manner, or contains additions and improvements to the plaintiffs' machine.